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REMEDIAL ACTION WORK PLAN FOR INJECTION AND RECIRCULATION OF EMULSIFIED OIL SUBSTRATE AT STUDY AREA 17 NTC ORLANDO FL

5/1/2006

CH2M HILL

Remedial Action Work Plan
Injection and Recirculation of Emulsified Oil Substrate (EOS®) at Study Area 17
Former Naval Training Center Orlando
Orlando, Florida

Revision No. 01

Contract No. N62467-01-D-0260
Task Order No. 0006

Submitted to:

U.S. Naval Facilities
Engineering Command
Southern Division

Prepared by:

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Remedial Action Work Plan

Injection of Emulsified Oil Substrate (EOS®) at Study Area 17
Former Naval Training Center Orlando
Orlando, Florida

Revision No. 01

Contract No. N62467-01-D-0331
Task Order No. 0006

May 2006

Prepared/Approved By:

________________________________ June 5, 2006
Sam Naik, Project Manager Date

Approved By:

________________________________ June 5, 2006
Craig Miller, Program Manager Date

Client Acceptance:

________________________________ ________________
U.S. Navy Responsible Authority Date

CERTIFICATION PAGE
Final Remedial Action Work Plan
Injection, Extraction and Recirculation of Emulsified Oil Substrate (EOS®)
Study Area 17, Former Naval Training Center, Orlando, Florida

PROFESSIONAL ENGINEER'S CERTIFICATION

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or these persons directly responsible for gathering the information, the information submitted is, to be the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

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(Affix Seal)

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5/19/06

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Acronyms

AFCEE	Air Force Center for Environmental Excellence
AHA	Activity Hazard Analysis
AOC	Area of Contamination
ASTM	American Society for Testing and Materials
bls	below land surface
BRAC	Base Realignment and Closure
BWP	Basewide Work Plan
C&D	Construction and Demolition
CDR	Construction Documentation Report
CH2M HILL	CH2M HILL Constructors, Inc.
CFR	Code of Federal Regulations
CO	Contracting Officer
COC	constituents of concern
CPM	Critical Path Method
CPR	Contractor Production Report
CQCR	Contractor Quality Control Report
CSM	Conceptual Site Model
CTO	Contract Task Order
CVOC	chlorinated volatile organic compound
DCE	dichloroethene
1,1-DCA	1,1-dichloroethane
1,1-DCE	1,1-dichloroethene
DFOW	definable features of work
DNAPL	dense non-aqueous phase liquid
DPDO	Defense Property Disposal Office
DPT	direct push technology
DQL	Data Quality Level
EBP	Enhanced Bioremediation Process
ECR	Environmental Conditions Report
EGIS	Environmental Geographic Information System
EOS®	Emulsified Oil Substrate
ERD	enhanced reductive dechlorination
EVS	Environmental Visualization System
FAC	Florida Administrative Code
FDEP	Florida Department of Environmental Protection

FL-COMQAP	FDEP-Approved Comprehensive Quality Assurance Plan
ft^2	square feet
GPS	Global Positioning System
HDPE	High density polyethylene
IDW	investigative derived waste
IRA	interim remedial action
IR CDQM	Installation Restoration Program Chemical Data Quality Manual
IRP	Installation Restoration Program
JV-II	Agviq-CH2M HILL Joint Venture
LDR	Land Disposal Restriction
LUCIP	Land Use Control Implementation Plan
μg/L	micrograms per liter
mg/L	milligrams per liter
ml	milliliter
nM	nanomoles
MIP	membrane interface probe
MNA	monitored natural attenuation
MS4	Municipal Separate Storm Sewer System
MSDS	Material Safety Data Sheets
msl	mean sea level
NAVFAC	Naval Facilities Engineering Command
NELAP	National Environmental Laboratory Accreditation Program
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
NRC	National Response Center
NTC	Naval Training Center
NTR	Navy Technical Representative
O&M	Operations and Maintenance
PAH	polynuclear aromatic hydrocarbon
PCBs	polychlorinated biphenyls
PID	Process and Instrumentation Diagram
PPE	personal protective equipment
ppm	parts per million
PVC	polyvinyl chloride
QC	Quality Control
RA	Remedial Action
RAO	Remedial Action Objective

RAWP	Remedial Action Work Plan
RCRA	Resource Conservation and Recovery Act
ROICC	Resident Officer in Charge of Construction
RPM	Remedial Project Manager
SA	Study Area
SAP	Sampling and Analysis Plan
SOPs	standard operating procedures
TCE	trichloroethylene
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
T&D	transportation and disposal
TO	Task Order
TRPH	total recoverable petroleum hydrocarbons
TSD	treatment, storage, or disposal
TSSDS	Tri-Service Spatial Data Standards
TTZ	target treatment zone
UIC	Underground Injection Control
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
VC	vinyl chloride
VOCs	volatile organic compounds
ZOD	Zone of Discharge

1.0 Introduction

AGVIQ-CH2M HILL JV-II (JV-II) has been contracted by the Department of the Navy, Naval Facilities Engineering Command, Southern Division (NAVFAC EFD SOUTH), to prepare this site-specific Remedial Action Work Plan (RAWP) under Contract No. N62467-03-D-0260 (the Contract), Task Order (TO) No. 0006.

The scope of work under this TO is to perform groundwater remediation at Study Area 17 (SA 17), Naval Training Center (NTC) Orlando, Orlando, Florida, utilizing subsurface injection of Emulsified Oil Substrate (EOS®), followed by extraction and recirculation, and finally a period of monitored natural attenuation (MNA).

The objective of the EOS® injections at SA 17 is to treat source area groundwater and subsurface soil contaminated with chlorinated volatile organic compounds (CVOCs) in situ, down to the confining unit which lies approximately 50 feet below land surface (bls) at the site.

The remedial action objectives for the source area treatment are to:

- Apply treatment that can reduce source contaminant concentrations while minimizing CVOC migration from the area.
- Prevent plume expansion into the interim remedial action (IRA) treatment area which was previously treated during 2003.
- Prevent exposure of contaminants to human health and the environment.

1.1 Site Description

SA 17 is located at the former NTC Orlando, a former Navy facility located in the city of Orlando, Florida. SA 17 occupies approximately 25 acres in the central part of the McCoy Annex of the NTC. The site includes Buildings 7178, 7191, 7193, and the adjacent area that formerly served as the Defense Property Disposal Office (DPDO) complex for the McCoy Annex. Figure 1-1 shows the site location.

Previous site activities related to a motor pool area have contributed to subsurface soil and groundwater contamination from trichloroethene (TCE). Elevated concentrations of TCE have been detected in a suspected source area at the site. The highest total chlorinated (CVOC concentration at the site detected during previous investigations was 577,000 micrograms per liter (µg/L) during the membrane interface probe (MIP) investigations conducted in the source area during September 2003. This source area has been targeted for contaminant reduction and has been designated as a target treatment zone (termed TTZ-1). Additional information on previous site investigations has been summarized in the *Optimization Report for Study Area 17, Former NTC Orlando* (CH2M HILL, 2005).

The CVOC contamination within the TTZ-1 extends vertically through the surficial aquifer from the water table (approximately 5 feet bls) to the top of a confining layer at an approximate depth of 50 feet bls. The lateral footprint of the source area is approximately 50 feet long and 50 feet wide. The vertical treatment zone is approximately 45 feet deep.

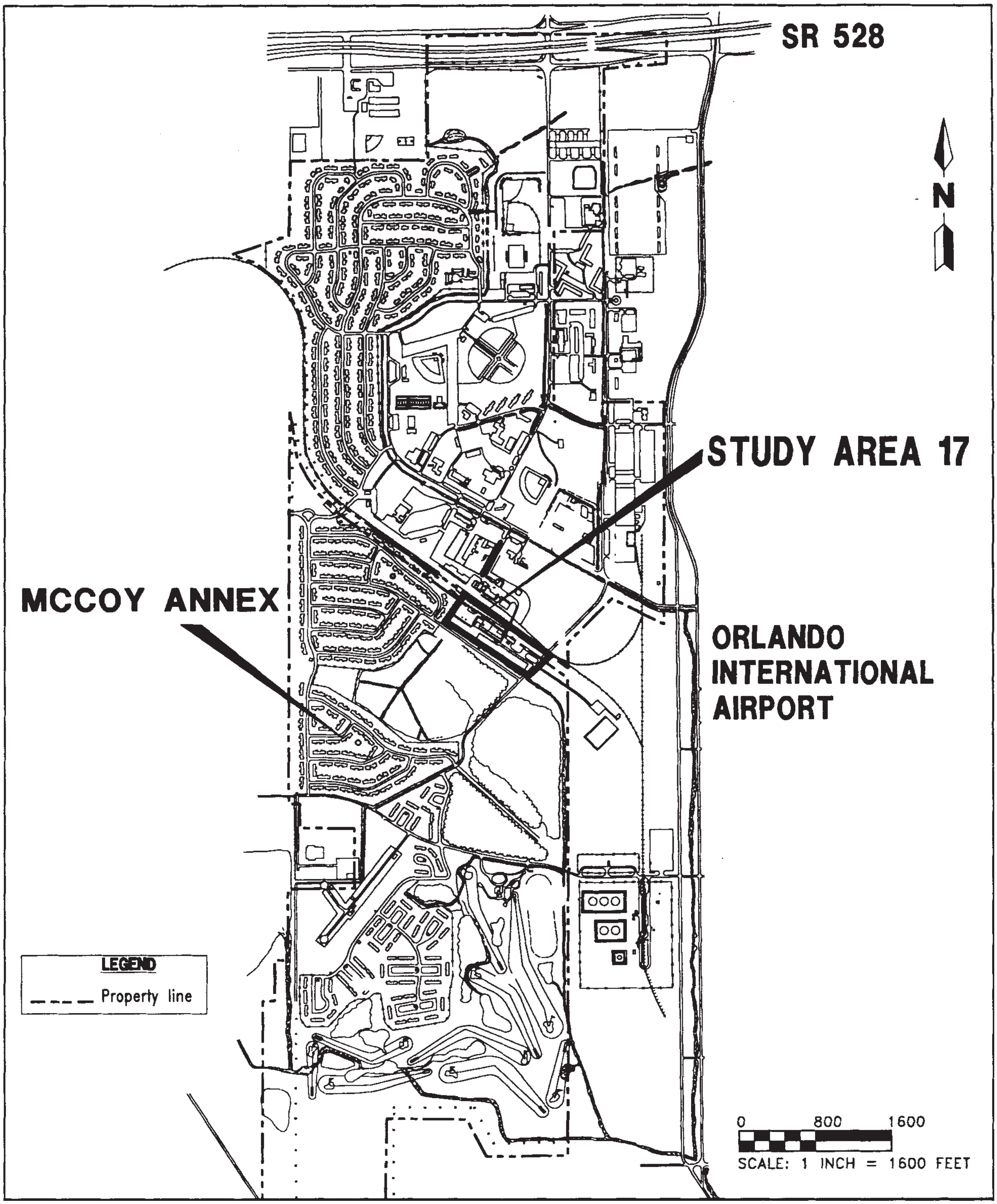


FIGURE 1-1
Site Plan
Study Area 17, Naval Training Center
Orlando, Florida

JV-II has been contracted by the Naval Facilities Engineering Command, Southern Division (the Navy) to conduct a remedial action (RA) to reduce the concentrations of TCE in the TTZ and minimize impacts to downgradient areas of SA 17.

Based on a technical evaluation and optimization study conducted by JV-II to evaluate the feasibility of available technologies to treat the subsurface contamination at this site, injection, extraction and recirculation of EOS® has been selected as the remedy to be implemented at SA 17.

Numerous groundwater monitoring wells currently exist in and around the treatment area. Some of these wells, in conjunction with new monitoring wells to be installed as part of this RA, will be utilized in establishing baseline groundwater conditions prior to EOS® injections and for quarterly performance monitoring.

1.2 Regulatory Background

The project is being conducted as part of the Base Realignment and Closure (BRAC). Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) regulations governing the treatment and handling of wastes have been followed at this site. Applicable Florida Administrative Code (FAC) Chapter 62 regulations will also be followed in the performance of the scope of work detailed in this plan.

1.3 Purpose of RAWP

The purpose of this Work Plan is to outline the procedures to be followed in performing groundwater remediation at SA 17 located at the former NTC Orlando. This Work Plan serves as a site-specific supplement to the *Basewide Work Plan, Revision No. 1, NTC Orlando, Orlando, FL* (CH2M HILL, 1998) (BWP), and is prepared to fulfill the general requirements of the Statement of Work of this TO.

1.3.1 Report Organization

This Work Plan is organized into nine sections of text and seven appendices, as summarized below. Relevant material from the Basewide Work Plan (BWP) prepared for the Response Action Contract with the Navy has been incorporated into this Work Plan for consistency of procedures.

Section 1.0, Introduction includes the site history, regulatory background and the project objectives.

Section 2.0, Basis of Remedial Design summarizes previous site characterization activities at SA 17, discusses the evaluation of various remedial alternatives, and provides details on the proposed design and implementation of the selected remedial alternative at the project site.

Section 3.0, Overview of Remedial Action provides a description of the bioremediation process being used for this RA including the basis for the injection and extraction wells, recirculation process control and performance monitoring.

Section 4.0, Remedial Action Construction, includes the required scope of work (project requirements) to include regulatory framework; the project schedule; detailed descriptions of pre-injection activities, approach to injection, extraction, and monitoring well installation; start-up and operation of EOS® Recirculation System; and reporting requirements. A detailed project schedule is provided in Appendix A of this Work Plan.

Section 5.0 Sampling and Analysis Plan provides project sample locations, sample collection frequencies, and the required laboratory analyses for samples collected during project activities. Additional information is also included on quality assurance and quality control samples.

Section 6.0, Waste Management Plan discusses the characterization, disposal, onsite management, and transportation of wastes (i.e., well development water, decontamination water, drill cuttings, etc.) encountered or generated while performing the scope of work under this contract at SA 17.

Section 6.0, Environmental Protection Plan, is supplemental and specific to the activities at SA 17 under this scope of work. The BWP addresses general environmental protection issues for remediation activities conducted at the former NTC Orlando.

Section 7.0, Stormwater Pollution Prevention Plan, discusses the specific Federal, State and local stormwater permits required, if any, for stormwater discharges resulting from construction activities at the site.

Section 8.0, Quality Control Plan, includes the testing requirements for work described in this Work Plan. The site-specific project organization for this TO is also included in this section. The Submittal Register, Testing Plan and Log, and Project Quality Control (QC) Manager documentation are provided in Appendix B, C, and D, respectively. All other quality control information is contained in the Basewide Work Plan, including information on the quality administrators, the project organization for the work to be completed at former NTC Orlando, and the definable features of work for each project site.

Section 9.0, References, lists all works cited in this Work Plan.

The following support documents are presented as appendices to this Work Plan.

- Appendix A Project Schedule
- Appendix B Submittal Register
- Appendix C Testing and Planning Log
- Appendix D QC Manager Documentation
- Appendix E Site-specific Health and Safety Plan
- Appendix F Copy of EOS® Quantity Calculation Worksheets
- Appendix G Copy of Optimization Study Report for SA 17, NTC Orlando
- Appendix H Copy of Aquifer Pump Test Report and Groundwater Flow Simulation Modeling Report
- Appendix I Evaluation of EOS® Viscosity Effects on Hydraulic Conductivity and Well Filter Pack Specifications

2.0 Basis of Remedial Design

2.1 Summary of Previous Site Characterization Activities

The environmental activities at SA 17 date back to 1995, where initial site screening of soil, surface water, sediment, and groundwater were performed by ABB Environmental Services, Inc. (ABB). Findings from these investigations indicated exceedances of screening criteria for polynuclear aromatic hydrocarbons (PAHs) in soil, and CVOCs in groundwater. Since then supplemental site screening investigations and an IRA site investigation have occurred to complete the delineation (nature and extent) of the subsurface contamination and have provided additional information on site-specific geologic conditions, especially as they relate to the potential implementation of specific interim remedial actions.

CVOCs adversely impacted the groundwater throughout the surficial aquifer and in isolated areas within the upper part of the intermediate aquifer of the Hawthorn Group sediments. Given the contaminant distribution pattern, the plume appeared to have originated from two release points at the surface located in the western and central parts of the former motor pool area. In the western source area, compounds detected at the highest concentrations were cis-1,2-DCE and vinyl chloride with a maximum concentration of 400 µg/L. In the eastern source area, TCE was the predominant compound detected, with a maximum concentration of 577,000 µg/L. The highest contaminant concentrations were detected at the water table interface in the source areas and along the upper surface of a silty sand layer that is located between 15 and 25 feet bls. This layer and another somewhat deeper layer of silty sand act as apparent aquitards that divide the surficial aquifer into three units – shallow, intermediate, and deep.

As a result of the Phase I/II site characterization efforts, the interpreted areal extent of the plume extended at the water table interface from both source areas for a distance of approximately 50 to 100 feet in the direction of groundwater flow (east-southeast). In the intermediate unit of the surficial aquifer, the plume extended to a distance of approximately 250 feet downgradient, and in the deep unit of the aquifer, the plume extended approximately 300 feet from the source areas.

Recent activities at SA 17 include a *Construction Documentation Report* (CDR) for the IRA (August 2003), *Technical Memorandum CVOC Source Area Investigation Results and Focused Feasibility Study*, and the *Optimization Report for SA 17* (March 2005). The following section summarizes the findings of the Optimization Report.

2.1.1 Summary of Optimization Report for SA 17

The Optimization Report for SA 17 supports the ongoing remedial efforts at SA 17 by incorporating remedy optimization concepts in the remedy selection phase of the Environmental Restoration program.

The groundwater contamination plume has been delineated into three major areas - Area 1, the source area (further designated as target treatment zone 1(TTZ-1); Area 2, contaminated groundwater plume downgradient of the source area and extending to the property boundary; and Area 3, groundwater at the property boundary. TTZ-1 encompasses all areas with groundwater and soil TCE concentrations greater than 10,000 µg/L. Based on three-dimensional kriging, TTZ-1 has been defined as an area 50 feet long, 50 feet wide, and approximately 50 feet deep, and is the focus of the remedial action described in this work plan (See Figure 2-1).

Based on an evaluation of available treatment technologies, two technology alternatives were proposed for SA 17 to remedy the elevated CVOC concentrations present in the source area. The two alternatives examined were:

- Alternative 1 – excavation and onsite treatment of contaminated soil with backfill of treated soil;
- Alternative 2 – enhanced reductive dechlorination (ERD) by either recirculation mode or injection followed by chase water. EOS® was chosen as the commercial substrate to facilitate ERD.

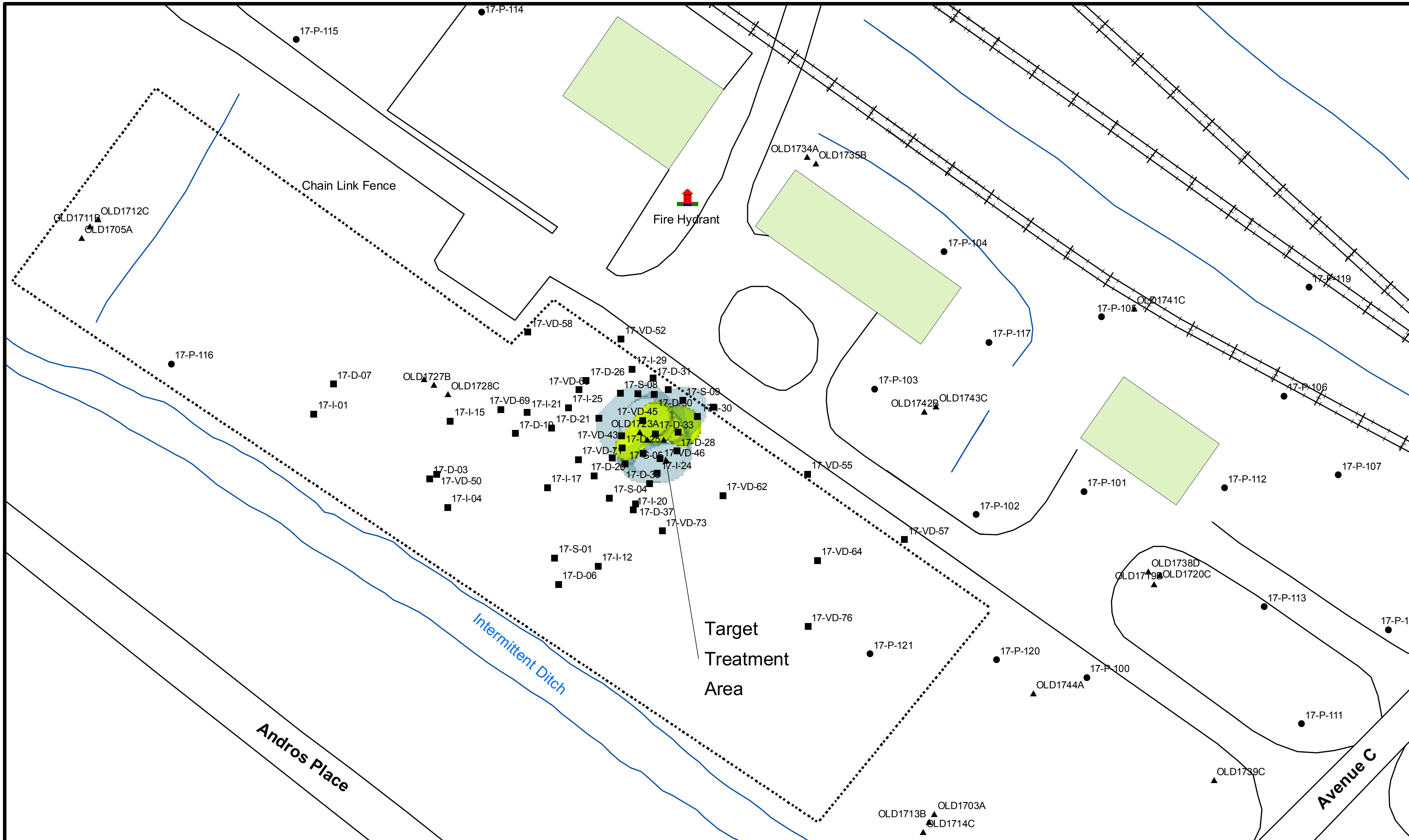
After comparison of the alternatives for their effectiveness, "implementability," uncertainty, and cost, the Optimization Report suggested using Alternative 2 with the groundwater recirculation option for implementation because it provides a cost-effective means of meeting the remedial action objectives (RAOs) and provides superior substrate delivery via the recirculation process.

Additionally, the Optimization Report recommended that groundwater monitoring wells be installed in Area 1 at a depth of 40 to 50 feet to verify TCE concentrations at this depth, and at the downgradient boundary in Area 3 to ensure that RAOs for Area 3 are achieved. The report also recommended that groundwater and surface water samples near and in the ditch south of TTZ-1 be collected to delineate the extent of contamination. A copy of the Optimization Report for SA 17 is included in Appendix G.

2.1.2 Hydrogeology

Previous site investigations at SA 17 have provided significant information on the hydrogeology at SA 17. The water table is at approximately 6 feet below land surface (bls) across the site, with a variation of 2 feet. The surficial aquifer extends to a depth of about 50 feet bls with its lower extent defined by the uppermost Hawthorn clay layer. Figure 2-2 depicts the geologic cross-section of the site used to distinguish the aquifer depth intervals at SA 17.

The groundwater elevation data indicates a radial flow away from a groundwater high located across the central portion of SA 17. The location of a buried water-supply line that runs across SA 17 suggests that leakage from the line may have been responsible for the localized groundwater high and resulting radial discharge observed in past investigations. This water line has since been turned off. The groundwater flow direction in the intermediate portion of the aquifer, between the upper two silty-sand intervals (15 to 30 feet bls) suggests that local recharge may also influence this interval. Flow in the intermediate zone is towards the ditch to the south, but a component of flow also exists to the east.



Legend

Ground Water Wells

- DPT Loactions
- Injector Wells
- Monitoring Wells

N

0 20 40 60 80 Feet

CH2MHILL

Figure 2-1
Target Treatment Area
and Site Features
SA-17, NTC Orlando

\\Boomer\projects4\NTC Orlando SA17\SA17 GIS\Sept2005_MXD_Files\Figure_2.1.mxd Edit Date: 3/13/2006 Editor: D. Magee

LEGEND

273 Trichloroethylene (µg/l) concentration from Phase II Confirmatory Sampling

101 Chlorinated hydrocarbon concentration (µg/l) from Screening Report

ND Not detected

(µg/l) Micrograms per liter

BRAC Base realignment and closure

DPT Direct-push technology

msl Mean sea level

Water table surface

(SP) Unified Soil Classification System symbol

(SM) Silty SANDS, SAND and silt mixture

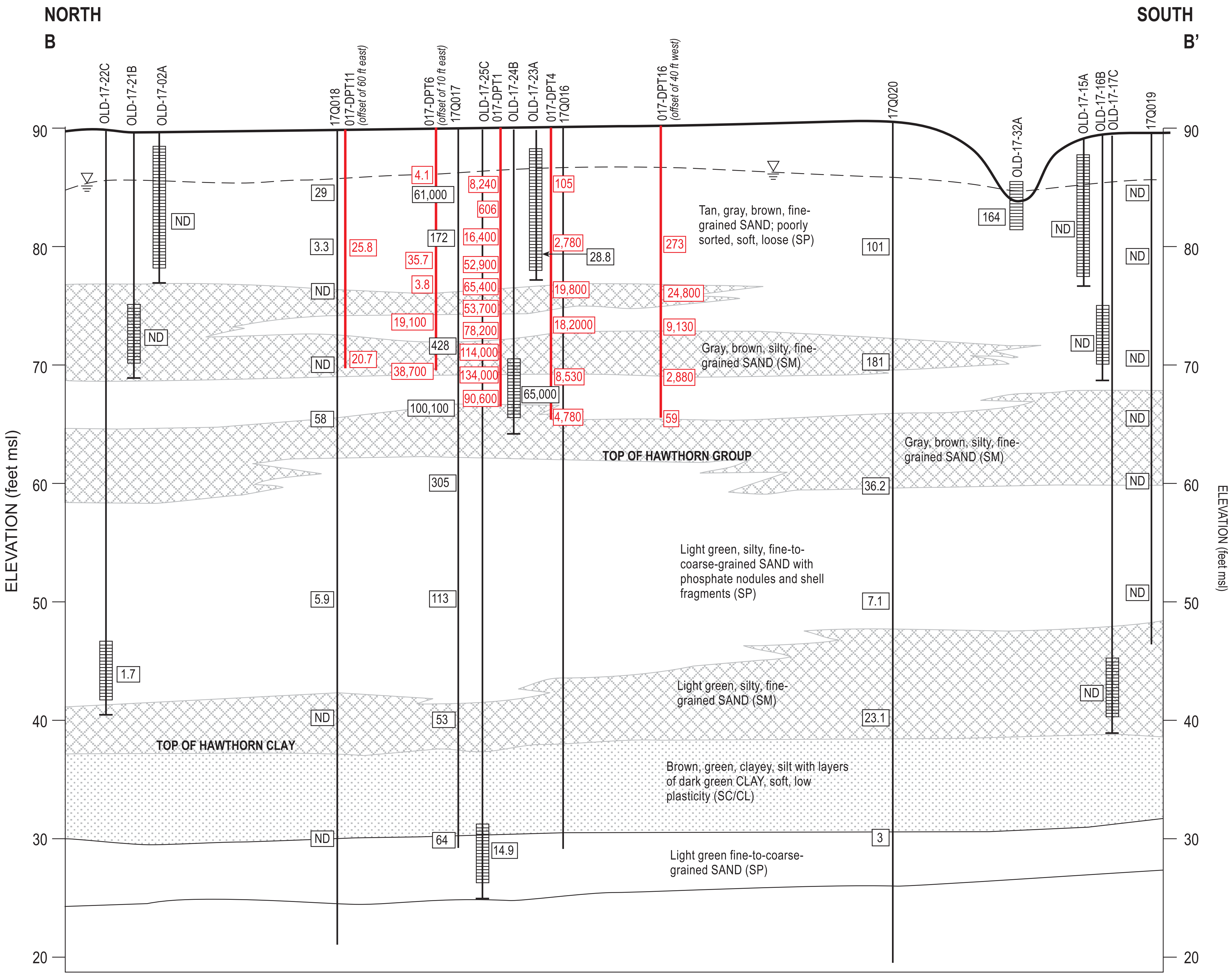
(SC/CL) Clayey SANDS, SAND and CLAY mixtures/inorganic CLAYS of low to medium plasticity

OLD-17-18A Monitoring well, Screen, Total depth of boring

17Q022 DPT well

0 5 10
Vertical Scale: 1 inch = 10 feet

0 25 50
Horizontal Scale: 1 inch = 50 feet



Plan View of Lithological Cross Section

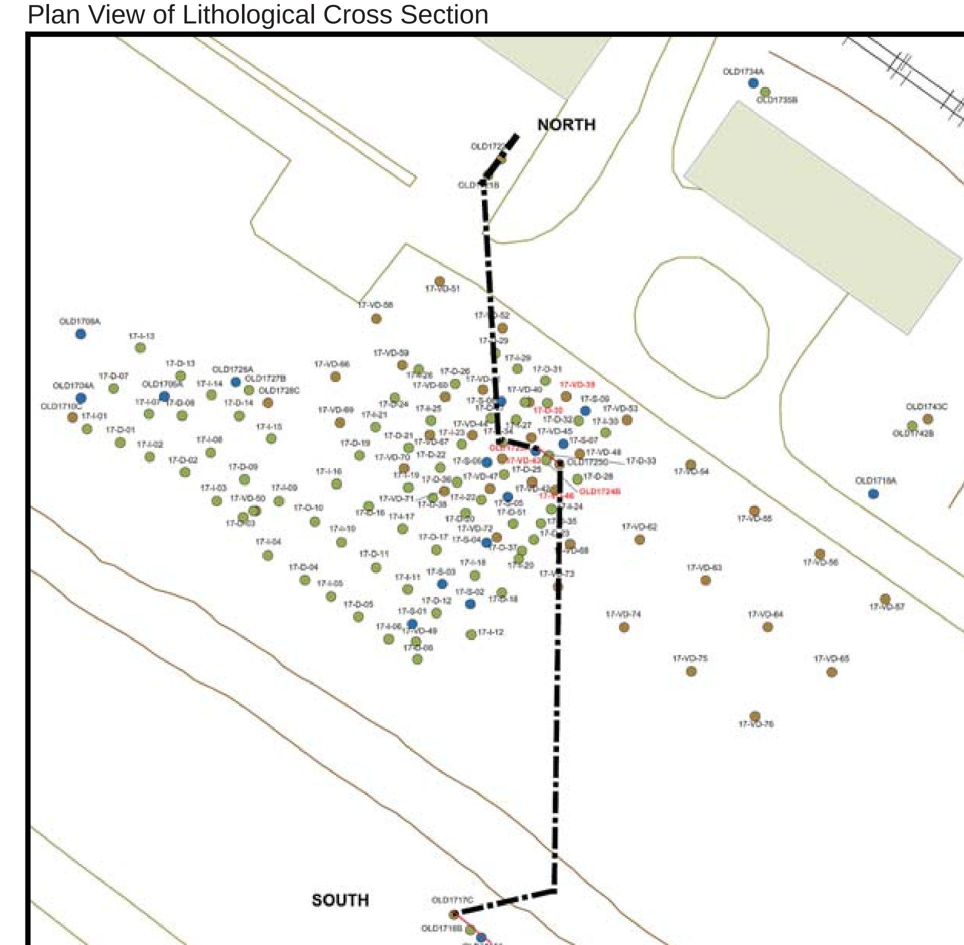


FIGURE 2-2
Lithologic Cross Section
Studay Area 17, Naval Training Center Orlando, Florida

Groundwater flow direction in the deep portion of the aquifer, below the lower silty sand interval (greater than 30 feet), suggests that local recharge has no influence in this interval. Flow in the deep zone is toward the south and east. Contaminant migration indicates a northerly component to the deep groundwater flow further east from the site. Groundwater flow across the site has a strong downward component. The groundwater seepage velocity at the site is low, ranging from approximately 3 to 7 feet per year depending on depth (CH2M HILL, 2003). Groundwater flow direction in the A (5 to 15 feet bls) and B zones (15 to 30 feet bls) (south and southeast respectively) is governed primarily by the ditch that runs south of the site. The C zone (30 to 55 feet bls) follows a more regional gradient (northeast). Figures 2-3, 2-4, and 2-5 show the groundwater potentiometric maps for the shallow, intermediate and deep zones of the shallow aquifer, based on groundwater elevations measured during the August 2004 groundwater sampling event.

The horizontal gradient ranges from 0.003 to 0.004 feet/foot. A downward vertical hydraulic gradient of 0.007 to 0.020 feet/foot exists within the surficial aquifer except near the drainage ditch, where groundwater discharges to the ditch and an upward gradient of approximately 0.25 feet/foot exists. Hydraulic conductivity was calculated based on the August 2005 aquifer pump test to be 4.7 feet/day in the surficial aquifer, and 6.9 feet/day in the deeper intervals of the surficial aquifer.

2.1.3 DNAPL Distribution

Dense non-aqueous phase liquid (DNAPL) was not observed in any of the sampling efforts at SA 17 but is suspected to be present based on the 1 percent rule of thumb (i.e., TCE > 1 percent of its solubility in water, or >11,000 μg/L). In the eastern source area of SA 17, TCE was the predominant compound detected, with a maximum concentration of 577,000 μg/L; therefore, there is potential of TCE DNAPL to be present based on concentration of TCE exceeding 11,000 μg/L. However, it is most likely present as ganglia representing small volumes of liquid in pore space and confined to the source area, or TTZ-1. The recurrence of elevated TCE concentrations after the in-situ chemical oxidation treatment and the persistent nature of the plume point to the presence of a potential DNAPL source or a highly-concentrated dissolved phase source within the target treatment zone.

NAPLANAL software was used to estimate a soil concentration which would likely indicate the presence of DNAPL. This concentration was estimated to be 342 mg/kg. The highest concentration of TCE reported in soil at SA 17 was 168 mg/kg. Although this value does not exceed the potential DNAPL calculated value, it does indicate the potential for elevated concentrations of TCE in soil act as a continuing source of contamination. Figure 2-6 shows a representation of areas in TTZ-1 suspected to potentially contain DNAPL-like concentrations of TCE.

2.1.4 Dissolved Phase Plume Distribution

The horizontal and vertical extent of CVOC contamination in the dissolved phase has been delineated for the areas hydraulically downgradient of the identified source area. Direct push technology (DPT) sampling and the installation of monitoring wells have successfully delineated contamination in three vertical zones in the shallow aquifer based on hydrogeological features; Zone A (5 to 15 feet bls), Zone B (15 to 30 feet bls), and Zone C (30 to 50 feet bls) as shown on Figure 2-7.

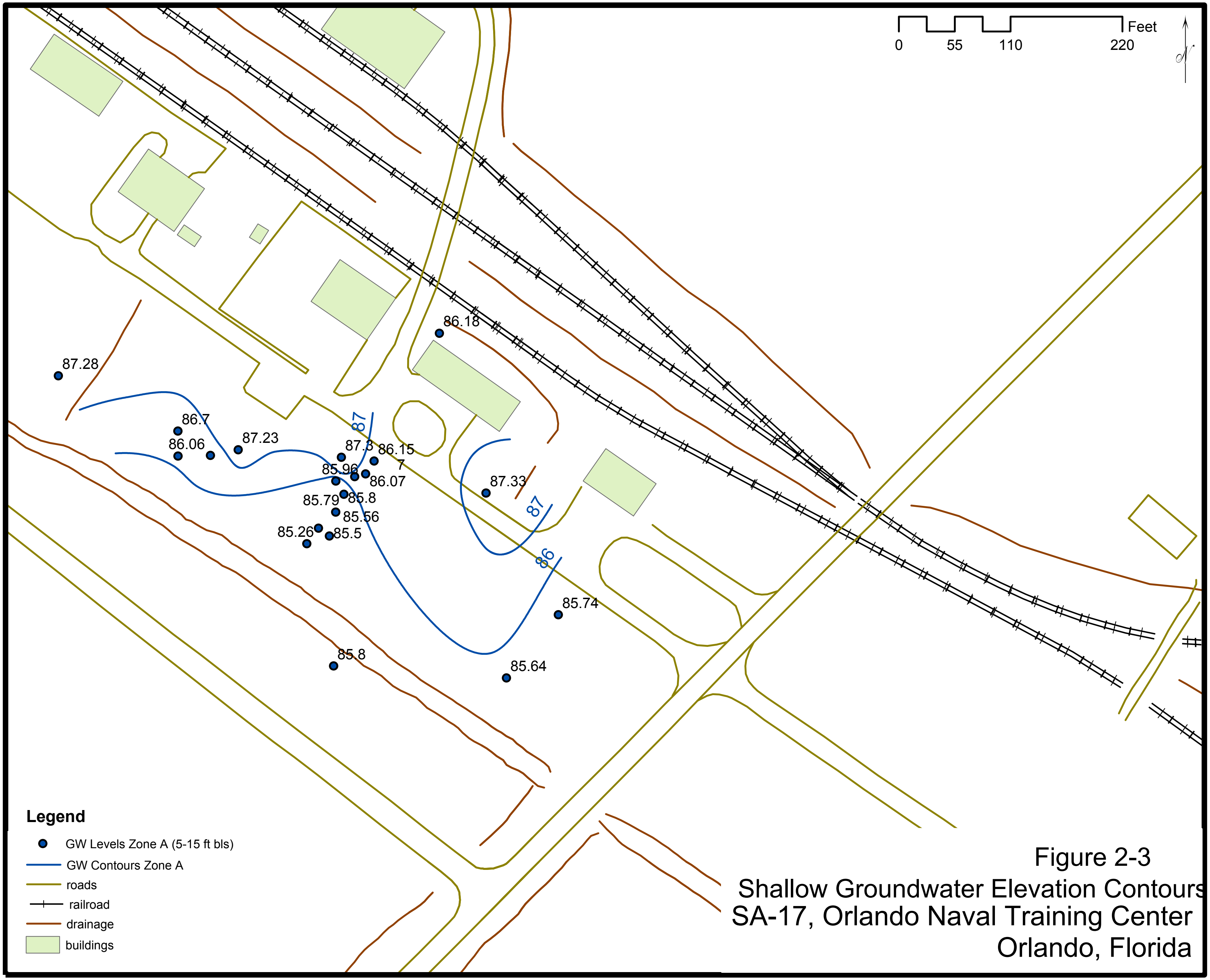


Figure 2-3
Shallow Groundwater Elevation Contours
SA-17, Orlando Naval Training Center
Orlando, Florida

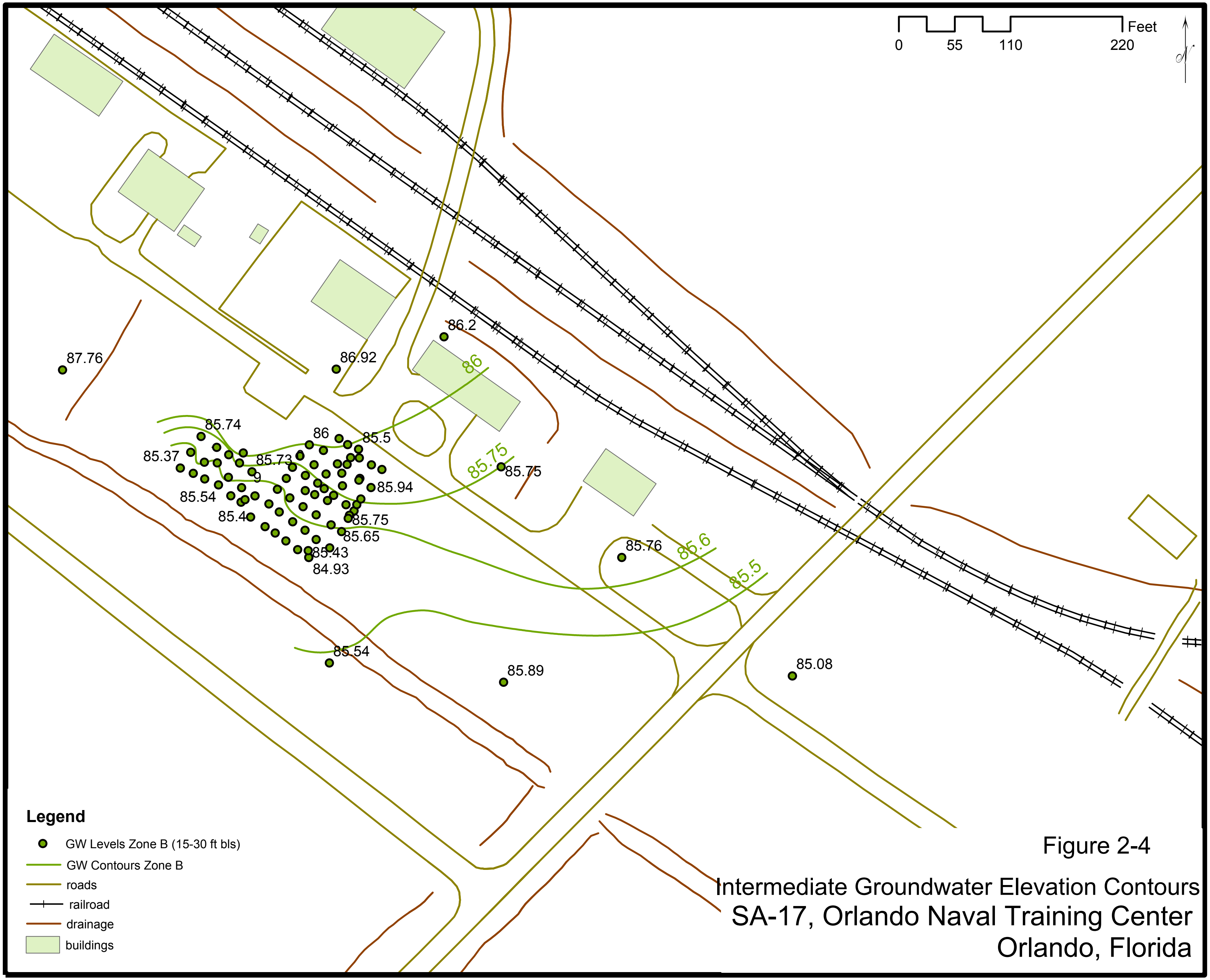


Figure 2-4

Intermediate Groundwater Elevation Contours
SA-17, Orlando Naval Training Center
Orlando, Florida

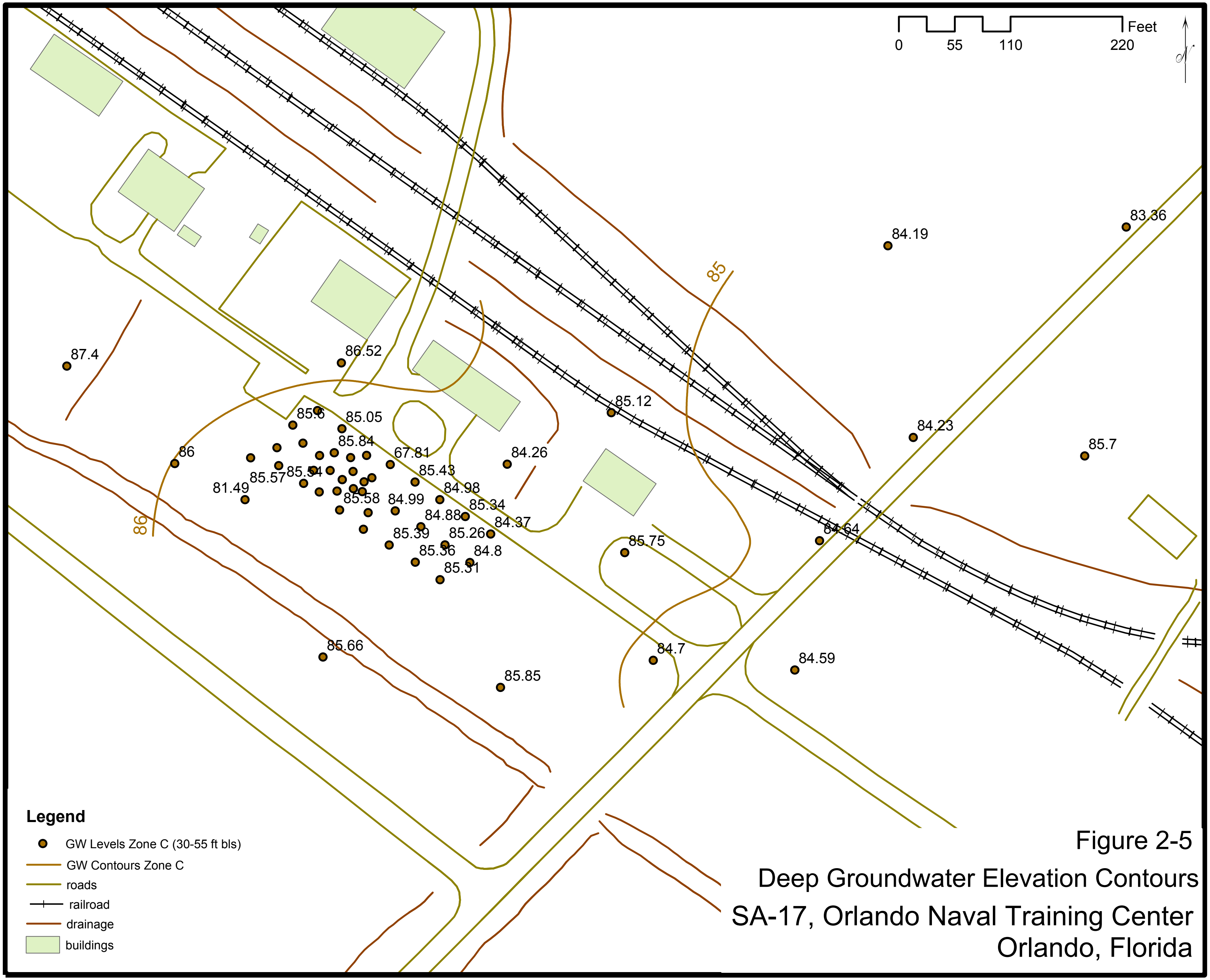


Figure 2-5

Deep Groundwater Elevation Contours

SA-17, Orlando Naval Training Center

Orlando, Florida

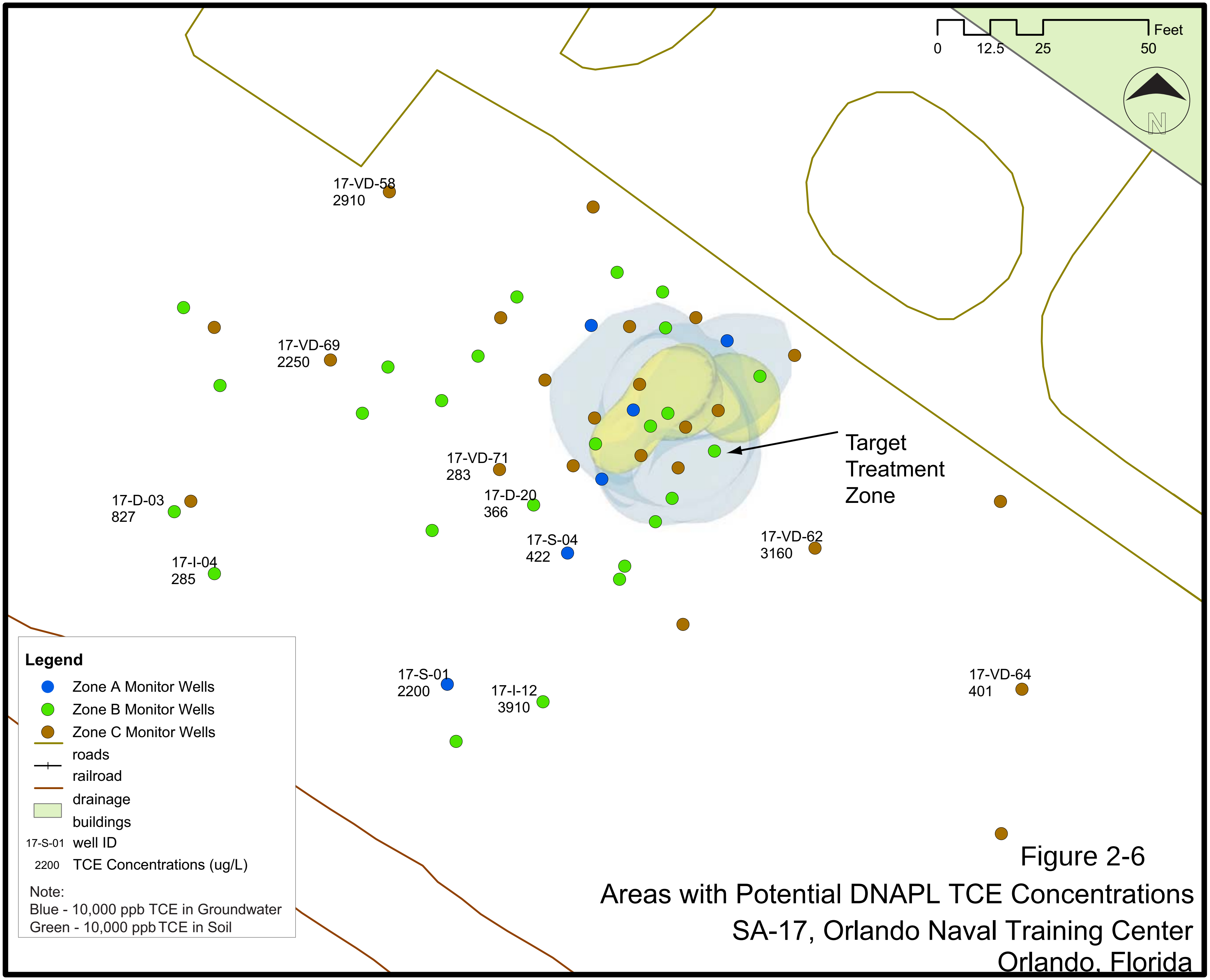


Figure 2-6
Areas with Potential DNAPL TCE Concentrations
SA-17, Orlando Naval Training Center
Orlando, Florida

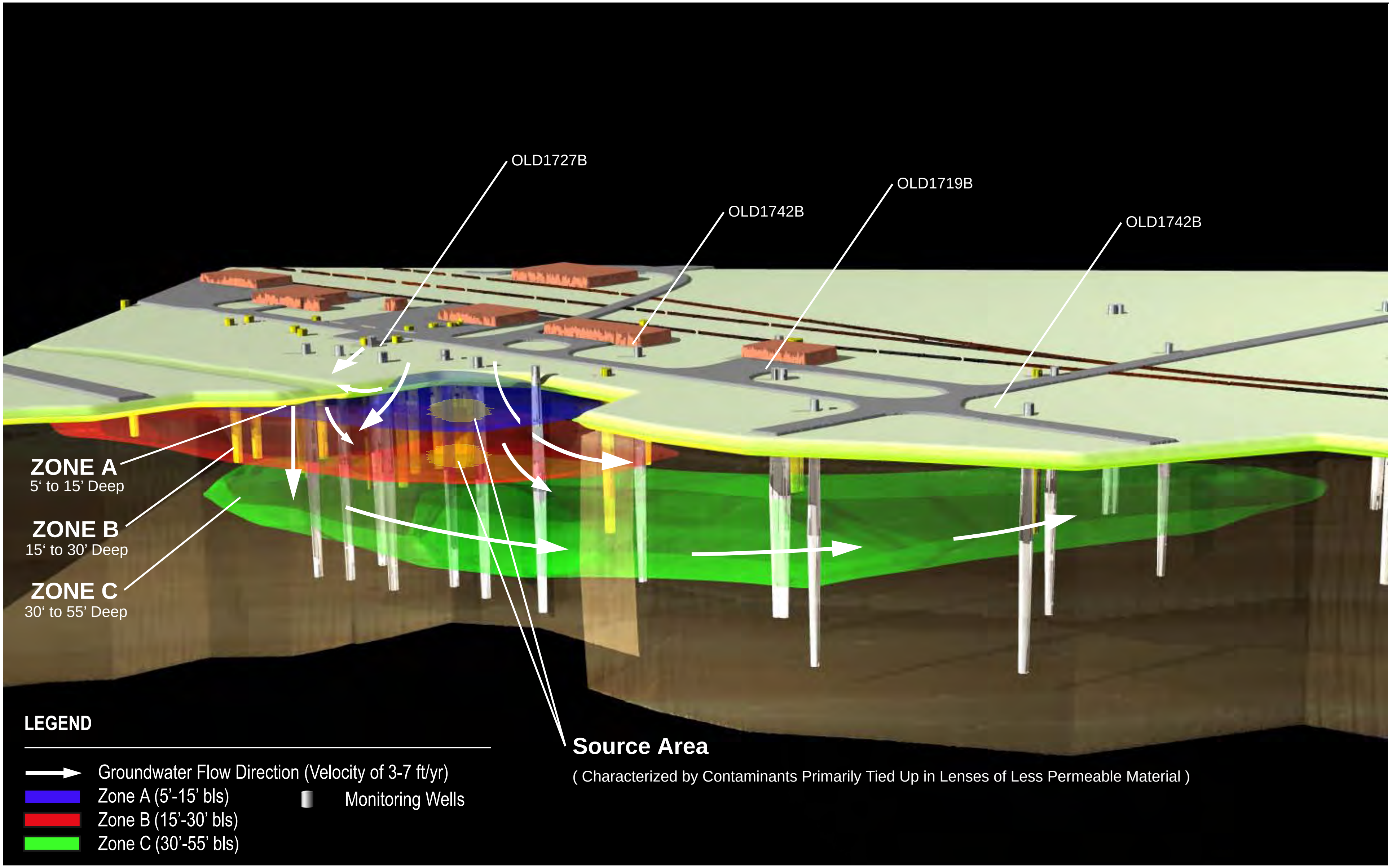


FIGURE 2-7
VOC Concentrations Above Criteria in Groundwater
SA17, Orlando Naval Training Center
Orlando, Florida

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As a result of the Phase I and II site characterization, the interpreted areal extent of the CVOC plume was defined as extending from the water table interface of the source areas for a distance of approximately 50 to 100 feet in the direction of groundwater flow (east-southeast direction). In the intermediate unit of the surficial aquifer, the plume extends approximately 250 feet downgradient, and in the deep unit of the aquifer, the plume extends approximately 300 feet from the source areas. These areas are depicted in Figure 2-8.

2.1.5 Groundwater Geochemistry

Extensive groundwater sampling was conducted at the SA 17 site between August and October 2004. The objectives of the sampling were to: 1) collect comprehensive groundwater data and update the interpretation of the extent of the groundwater contamination and 2) provide monitored natural attenuation (MNA) parameter data.

The comprehensive groundwater sampling effort involved collection of the following:

- Fifty groundwater samples were collected and analyzed for volatile organic compounds (VOCs) in the first sampling effort. These samples provided information regarding the extent of groundwater CVOC contamination.
- Fifty samples were also collected for MNA parameters. All of these samples were tested for dissolved oxygen (DO), oxidation reduction potential (ORP), and pH. Thirty-six wells were sampled and analyzed for sulfate, dissolved iron, dissolved manganese, alkalinity, and sulfide. Methane was analyzed in 30 samples and nitrate was analyzed in 25 samples. Thirteen samples targeted for MNA analyses were also sampled for hydrogen.

Eight wells were sampled for phospholipid fatty acids (PLFA) and Real-Time PCR analysis. These samples were collected from the hot spot area to determine the community structure of the native bacterial consortium in the area that was subjected to in-situ chemical oxidation. Figure 2-9 shows the locations of site monitoring wells.

A detailed discussion of the analytical results and findings of this sampling event was presented to the OPT in the document *Technical Memorandum: Summary of Data Collection Activities, Study Area 17, Former NTC Orlando* (CH2M HILL, February 2005). A summary of the findings related to groundwater geochemical conditions and microbial analyses conducted at the site is presented below.

2.1.5.1. MNA Results

MNA parameters were measured in 50 groundwater samples. Not all analyses were performed on samples from all wells. MNA parameters included alkalinity, DO, dissolved iron, dissolved manganese, nitrate, hydrogen, methane, ethane, ethene, nitrate, ORP, pH, sulfate, and sulfide. These data were collected to evaluate the terminal electron accepting processes (TEAP) likely occurring in groundwater at the site.

A substantial amount of MNA data was collected for the SA 17 assessment. The predominant TEAPs likely occurring were evaluated first using the methodology presented in the *Technical Guidelines for Evaluating Monitored Natural Attenuation of Petroleum Hydrocarbons and Chlorinated Solvents in Ground Water at Naval and Marine Corps Facilities*

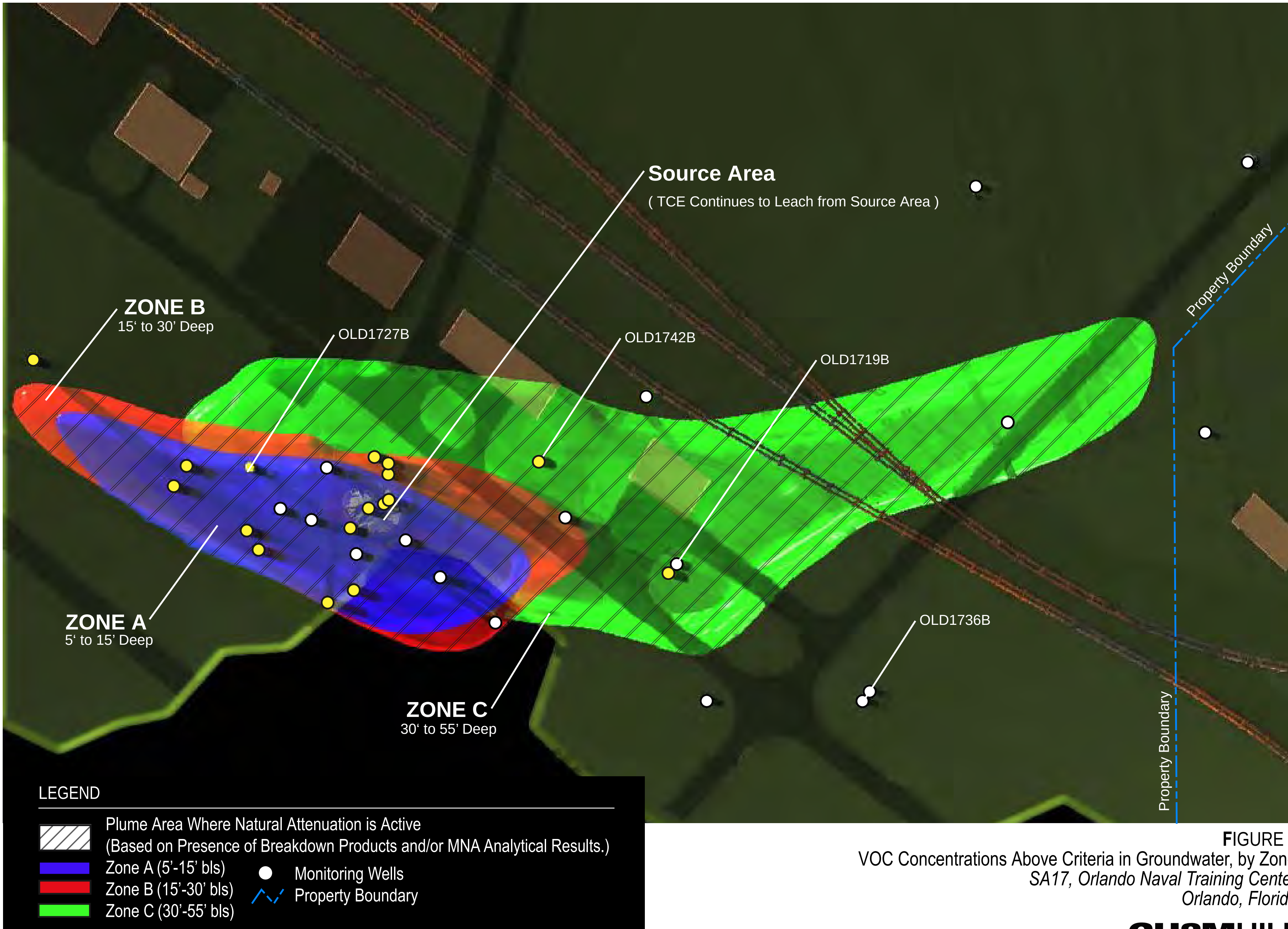

FIGURE 2-8
VOC Concentrations Above Criteria in Groundwater, by Zone
SA17, Orlando Naval Training Center
Orlando, Florida

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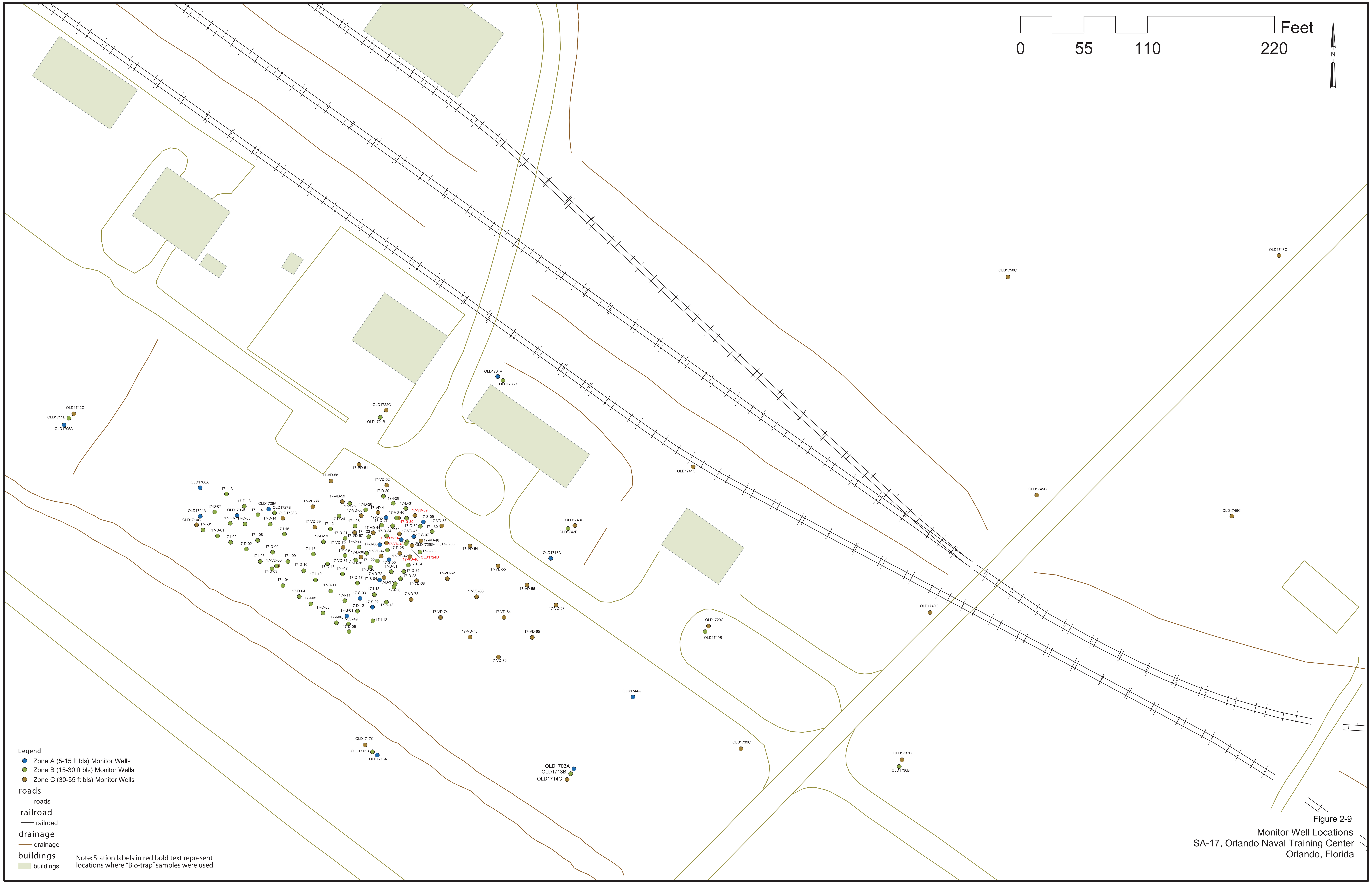

Figure 2-9
Monitor Well Locations
SA-17, Orlando Naval Training Center
Orlando, Florida

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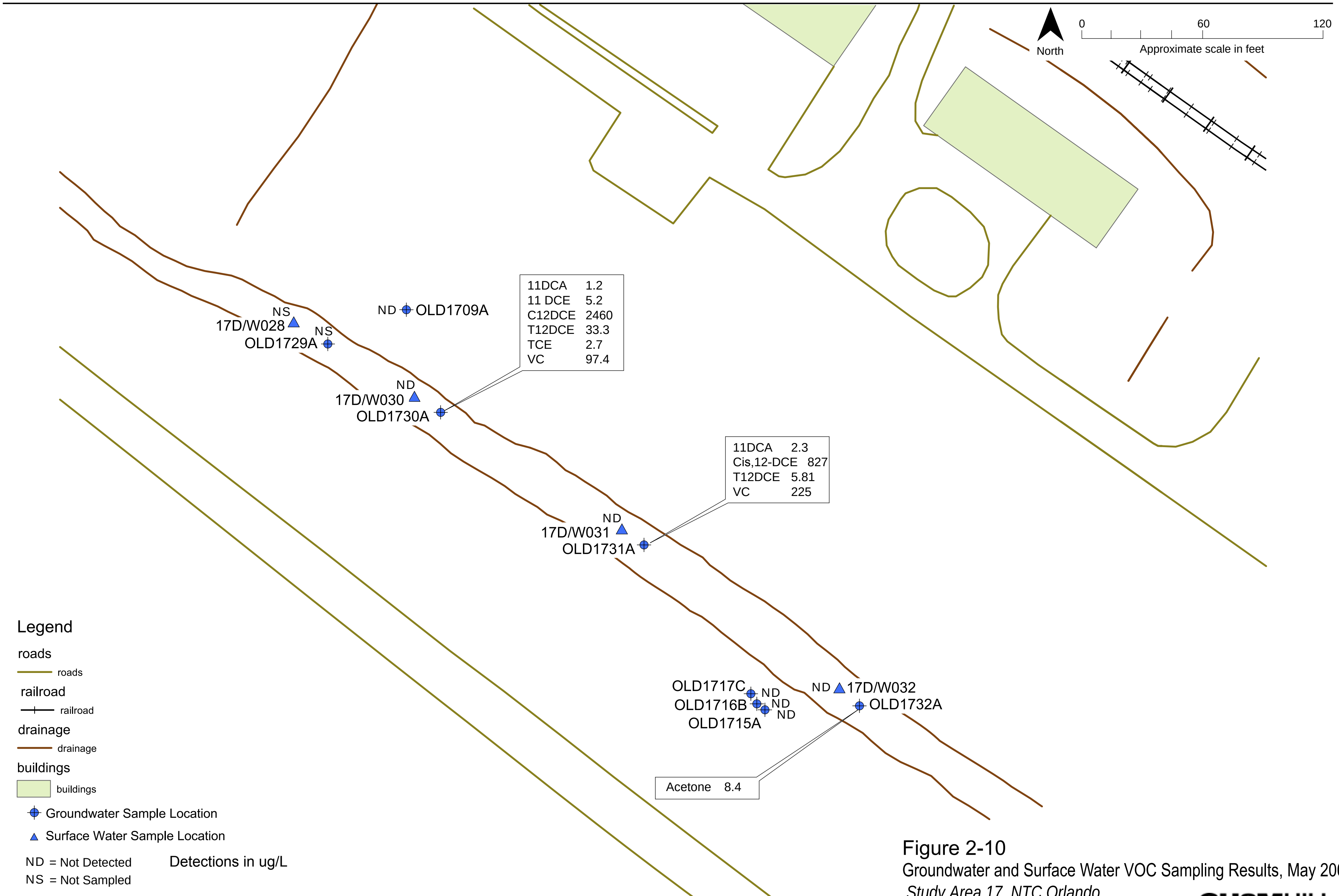


Figure 2-10
Groundwater and Surface Water VOC Sampling Results, May 2005
Study Area 17, NTC Orlando

CH2MHILL

ES012006012GNV_SA-17NTC__Fig_GW_SW_Sample_Locatons.ai

(Wiedemeier and Chapelle, September 1998). The evaluation using this method did conclude that aerobic respiration and nitrate reduction are likely not occurring at the site. However, the remainder of the data does not clearly point to a dominant TEAP using this method.

A more qualitative evaluation of the data was then conducted. Dissolved iron was observed in nearly all wells at a concentration above 1000 μg/L, a level generally considered indicative of iron reducing conditions. Iron was remarkably elevated in some wells, as high as 236,000 μg/L in one sample. Some of the very high iron readings may be due to residual impacts of the ferrous iron catalyst that was injected as part of the in-situ chemical oxidation activities using Fenton's reagent. The ORP measured in many wells is slightly reducing and generally in the range at which iron reduction may occur. Based on these observations, it is considered likely that some degree of iron reduction is occurring in the shallow aquifer.

It was not possible to determine whether sulfate reduction is occurring. Little sulfide was detected. However, because of the high dissolved iron, sulfide formed as a result of sulfate reduction may be precipitating out as ferrous sulfide. Therefore, the presence of sulfate reduction conditions is inconclusive. Like iron, the high levels of sulfate reported in some wells is likely due to residual impacts of the ferrous sulfate catalyst and the sulfuric acid used to adjust pH at the at the site to facilitate an optimal pH range for Fenton's reagent. Groundwater at SA 17 is slightly acidic, with pH ranging from 5.4 to 6.3, and total alkalinity ranging from 8.6 to 111 milligrams per liter (mg/L).

The presence of methane in several wells suggests methanogenesis is occurring to some degree in portions of the aquifer. Hydrogen, where sampled, generally showed concentrations between 1 and 4 nanomoles (nM), which may point to more of a sulfate reducing condition rather than iron reduction conditions. Finally, the presence of reductive dechlorination daughter products, including vinyl chloride, indicates that sulfate reducing and methanogenic conditions may be occurring in some portions of the aquifer.

Overall, the predominant TEAP in the shallow aquifer may be generally categorized as likely iron-reducing with some degree of sulfate reduction and methanogenesis also occurring. These conditions are favorable for MNA.

The ethane and ethene data support the conclusion that MNA is active at the site. Ethane and ethene are products of reductive dechlorination; their presence in groundwater is indicative of complete reductive dechlorination of CVOCs.

2.1.5.2 Microbial Analysis

Bio-Trap samplers were used to evaluate the microbial communities of six monitoring wells from the source area based upon their phospholipids fatty acid content (PLFA Analysis). Additionally, CENSUS (Real-Time PCR) was used to screen for the abundance of bacterial groups associated with reductive dechlorination (*Dehalococcoides*, Sulfate & Iron Reducing Bacteria (SRB/IRB), Methanogens, and *Geobacter*). A summary of the findings is presented below.

Six monitoring wells (OLD-17-VD39, OLD-17-VD43, and OLD-17-VD46, OLD-17-23A, OLD-17-D30 and OLD-17-24B) were used to install in the in situ microcosms used to collect microbial data. These wells had various levels of contaminants present. The levels of CVOC contaminants present are listed in Table 2-1.

TABLE 2-1
Detections of CVOCs in Wells Selected for Microbial Analysis

Location	TCE	cis-1,2-DCE	Vinyl Chloride	Sample Date
VD-39	0.58J	0.62J	ND	June 2003
VD-43	684	426	1.1	June 2003
VD-46	0.61J	60.5	0.4J	June 2003
D-30	544	0.32J	0.63J	August 2004
OLD-17-24B	202	8	ND	August 2004
OLD-17-23A	78.7	1	ND	August 2004

Values reported in µg/L.

Two monitoring wells (OLD-17-23A, and OLD-17- 24B) had both control and sodium lactate-baited Bio-Traps installed in an effort to assess the microbial response to the addition of sodium lactate.

Below is a brief discussion with respect to the results at each sample location. The monitor wells where two the Bio-Traps were installed (one control and one baited with sodium lactate) are discussed first, followed by the four monitor well results where only control Bio-Traps were installed.

Baited Bio-Traps

At OLD-17-23A, d*ehalococcoides* was present in both the control and baited Bio-Trap, indicating that the genetic potential for complete degradation of the contaminants. Sulfate and iron reducing bacteria increased with the addition of sodium lactate, which indicates there may be more competition for available hydrogen. The abundance of methanogens did not change with the addition of sodium lactate bait. As such, it appears that competition from methanogens did not increase significantly with this amendment. However, it should be noted that methanogens were detected at ~10^5 gene copies/mL so a sustained population of this type of bacteria was present in this well.

At OLD-17-24B, the observations from monitoring well OLD-17-24B suggest a high potential for rapid fermentation to occur upon the addition of lactate, which was quickly broken down to produce hydrogen and acetate. Methanogens (which increased two orders of magnitude in the baited Bio-Trap) could be utilizing available hydrogen and may be contributing to the absence of *dehalococcoides* at this sampling location through competition for hydrogen.

Control Bio-Traps

Results from Bio-Traps installed in wells OLD-17-D30, OLD-17-VD39, OLD-17VD-43, and OLD VD-46, along with results from the control Bio-Traps discussed previously, revealed the following:

- Estimated viable biomass ranged from 10^4 to 10^5cells/bead for all samplers and did not show a clear pattern in either well location or sampling depth.

- The microbial community structures varied considerably among the sampling locations.
- Biomarkers associated with anaerobic firmicutes (terminally branched PLFA) were detected in all six samples with the highest proportion in samples OLD-17-24B (42 percent) and OLD-17-VD-46 (33 percent). High proportions of firmicutes suggest the presence of fermenting bacteria (*clostridia/bacteriodes*-like), which are important at locations contaminated with chlorinated solvents because they produce the hydrogen necessary for reductive dechlorination.
- Physiological status biomarkers showed that the Gram negative proteobacteria in samples had signs of slowed growth rates (starvation). However, the levels seen were low to moderate, and are typical for samples from contaminated sites.
- CENSUS results confirmed the presence of *dehalococcoides* in samples OLD-17-23A (~10^3 gene copies/mL) and OLD-17VD46 (~10^1 gene copies/mL).

2.1.5.3 Overall MNA Assessment

Conclusions from the investigation can be summarized as follows:

1. Reducing conditions are evident in the source area, as well as downgradient of the source area, as site data points to evidence of predominantly iron reducing conditions, but some degree of sulfate reducing and methanogenic conditions at the site. These conditions are favorable for MNA.
2. The presence of TCE daughter products cis-DCE and vinyl chloride in downgradient wells relatively close to the residual TCE source area indicates that reductive dechlorination is occurring readily at the site. The relatively high ratio of daughter products to parent compound (TCE) indicates a high degree of biotransformation is occurring. This is favorable for MNA.
3. *Dehalococcoides* have been detected at two locations at the site. This is highly favorable for MNA, as *Dehalococcoides* organisms have been shown to be capable of complete reductive dechlorination of TCE and its daughter products to ethane. It is likely that *Dehalococcoides* can become established at other areas if an additional carbon source is added.

2.1.6 Surface Water and Groundwater Sampling in the Ditch

Surface water in the intermittent ditch located on the south side of the TTZ was sampled during May 2005 to verify impacts to surface water or groundwater beneath the ditch from the TCE contamination within the TTZ. Figure 2-10 shows the locations and detected TCE concentrations in surface water and groundwater samples collected during this sampling event.

As indicated on Figure 2-10 and in Table 2-2, no detections of CVOCs above laboratory detection limits in the surface water samples from the ditch were found. Two wells, OLD-17-30A and OLD-17-31A, showed low-level TCE contamination and significant detections of TCE-daughter products 1,2-dicholorothene and vinyl chloride. These wells are screened near the water table (approximately between 4 to 6 feet bls). The lack of TCE detections in the surface water indicates that the CVOC contamination is not impacting the surface water.

Table 2-2
Analytical Results from Supplemental Surface Water and Groundwater Sampling (May 2005)
Study Area 17, NTC Orlando

Station ID	**OLD-17-29A**	**OLD-17-15A**	**OLD-17-16B**	**OLD--17-17C**	**OLD-17-30A**	**OLD-17-31A**	**OLD-17-32A**	**17D/W-30**	**17D/W-31**	**17D/W-32**
Sample ID	**T021709AQ105**	**T021715AQ105**	**T021716BQ105**	**T021717CQ105**	**T021730AQ105**	**T021731AQ105**	**T021732AQ105**	**T0217SW030**	**T0217SW031**	**T0217SW032**
Sample Date	**03/11/2005**	**03/11/2005**	**03/11/2005**	**03/11/2005**	**03/11/2005**	**03/11/2005**	**03/11/2005**	**03/11/2005**	**03/11/2005**	**03/11/2005**
								Surface Water	**Surface Water**	**Surface Water**
Method-SW8260B										
Units in ug/L										
Parameter										
1,1,1-Trichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1,2,2-Tetrachloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1,2-trichloro-1,2,2-trifluoroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1,2-Trichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,1-Dichloroethane	1 U	1 U	1 U	1 U	**1.2**	1 U	1 U	1 U	1 U	1 U
1,1-Dichloroethene	1 U	1 U	1 U	1 U	**5.2**	**2.3**	1 U	1 U	1 U	1 U
1,2,3-trichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2,4-Trichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dibromo-3-chloropropane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dibromoethane (Ethylene dibromide)	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,2-Dichloropropane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,3-Dichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
1,4-Dichlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
2-Hexanone	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
Acetone	4 U	4 U	4 U	4 U	4 U	4 U	**8.4**	4 U	4 U	4 U
Benzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Bromochloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Bromodichloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Bromoform	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Bromomethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Carbon disulfide	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Carbon tetrachloride	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chlorobenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chloroethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chloroform	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Chloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
cis-1,2-Dichloroethene	1 U	1 U	1 U	1 U	**2460**	**827**	1 U	1 U	1 U	1 U
cis-1,3-Dichloropropene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
cyclohexane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Dibromochloromethane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Dichlorodifluoromethane	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
Ethylbenzene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Isopropylbenzene (Cumene)	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
methyl acetate	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Methyl ethyl ketone (2-butanone)	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
pentanone)	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U	2 U
methylcyclohexane	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Methylene chloride	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Styrene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
tert-butyl methyl ether	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U

Table 2-2
Analytical Results from Supplemental Surface Water and Groundwater Sampling (May 2005)
Study Area 17, NTC Orlando

Station ID	OLD-17-29A	OLD-17-15A	OLD-17-16B	OLD--17-17C	OLD-17-30A	OLD-17-31A	OLD-17-32A	17D/W-30	17D/W-31	17D/W-32
Sample ID	**T021709AQ105**	**T021715AQ105**	**T021716BQ105**	**T021717CQ105**	**T021730AQ105**	**T021731AQ105**	**T021732AQ105**	**T0217SW030**	**T0217SW031**	**T0217SW032**
Sample Date	**03/11/2005**	**03/11/2005**	**03/11/2005**	**03/11/2005**	**03/11/2005**	**03/11/2005**	**03/11/2005**	**03/11/2005**	**03/11/2005**	**03/11/2005**
								Surface Water	**Surface Water**	**Surface Water**
Method-SW8260B										
Units in ug/L										
Tetrachloroethene (PCE)	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Toluene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
trans-1,2-Dichloroethene	1 U	1 U	1 U	1 U	**33.3**	**58.1**	1 U	1 U	1 U	1 U
trans-1,3-Dichloropropene	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U	1 U
Trichloroethene (TCE)	1 U	1 U	1 U	1 U	**2.7**	1 U	1 U	1 U	1 U	1 U
Trichlorofluoromethane	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ	1 UJ
Vinyl chloride	1 U	1 U	1 U	1 U	**97.4**	**225**	1 U	1 U	1 U	1 U
Xylenes, total	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U	3 U

Notes:
Values Bold and Shaded are Hits
U - The analyte was analyzed for , but not detected.
J - estimated value
UJ- Value non-detected estimated.

2.2 Conceptual Site Model

Figures 2-7 and 2-8 present a conceptual site model (CSM) in plan and profile view. Based on historical information and current understanding of the site, the following information about the CSM for SA 17 can be concluded:

- The vadose zone is not a significant source of groundwater contamination and the groundwater in the SA 17 area is being contaminated from "source areas" within the saturated zone.
- TCE appears to have entered the ground at a surface location and migrating began vertically downward followed by a horizontal and further vertical migration extent.
- Given the current distribution of contaminants at the site (that is, known contaminant concentrations downgradient), no location immediately downgradient of the source area at SA 17 is anticipated to yield an offsite exceedance of the State of Florida GCTLs at any point in the future (CH2M HILL, 2005). Additional sampling of existing and new monitoring wells near the fenceline will be evaluated after the ERD implementation activities at the source area are completed.
- Recent surface water sampling in the intermittent ditch on the south side of the TTZ-1 showed no detections above laboratory detection limits for VOCs indicating that the source area contamination within TTZ-1 is currently not posing a threat to surface water quality in the ditch. No other surface water bodies are within the vicinity of the groundwater plumes at SA 17.

2.3 Design Criteria

2.3.1 Selection of Target Treatment Area

The proposed activities for the EOS® application were documented in the *Optimization Report for Study Area 17, Former Naval Training Center, Orlando* (CH2M HILL, 2005). The principal basis for the EOS® injection scheme is described in the following subsections.

The TTZ for the site represents the source area and is identified as TTZ-1 (Figure 2-1). This area contains the highest concentrations of TCE at SA 17. TTZ-1 encompasses all groundwater contamination reported with TCE greater than 10,000 µg/L in groundwater and TCE greater than 10,000 µg/kg in soil. Three dimensional kriging indicates that the areas with elevated CVOC concentration exceeding 10,000 µg/kg in soil and 10,000 µg/L in groundwater, to be approximately 50 feet long and 50 feet wide (approximate footprint area of 2,500 square feet).

The depth of TTZ-1 is from the water table (approximately 3 to 5 feet bls) to the top of the Hawthorne formation, which lies approximately 48 to 50 feet bls. A deep well (OLD-17-50-C) was installed in the middle of TTZ-1during May 2005, with the bottom of the well at a depth of 48 feet bls, with a screen interval from 42 to 47 feet bls. The groundwater sample collected from this well after installation showed low-level TCE contamination at 979 µg/L (compared to groundwater above this level), and indicates that the presence of DNAPL is unlikely at this depth. However, given the elevated level of TCE at this depth, the depth of the source area treatment zone is being extended to 50 feet bls.

For this remedy implementation, EOS® will be used to facilitate subsurface treatment by injecting the substrate via recirculation mode to encompass all three sub-zones of the shallow aquifer within the TTZ-1. Additional implementation details of the EOS® injection and recirculation are provided in Section 3.0.

2.3.2 Remedial Action Objectives

RAOs are medium-specific goals that the remedial actions are designed to accomplish to protect human health and the environment by preventing or reducing exposures under current and future land use conditions. The *Optimization Report for SA 17* (CH2M HILL, 2005) concluded that a substantial effort in the SA 17 source area treatment has already been completed and it is believed that the practical limits of cost effective remediation for the purposes of complete removal of the source have been exhausted.

Based on these conclusions, achieving a pre-defined source mass reduction or concentration reduction is not a component of the RAO for this site. However, it is important that the implemented alternative involve management of source area to prevent further groundwater contamination in the zone already treated by the IRA and to prevent contaminant migration away from the source area.

The RAOs for TTZ-1 are: 1) to apply treatment that can reduce source contaminant concentrations while minimizing CVOC migration from the area, 2) to prevent plume expansion in the target treatment area, and 3) to prevent exposure of contaminants to human health and the environment.

2.3.3 Performance Objective

Several performance objectives have been established for the RA as follows:

1. Achieve a constant substrate delivery using recirculation.
2. Determine optimum extraction and injection rates.
3. Optimize adequate distribution of EOS® in the subsurface, as measured by EOS® detection in intermediate monitoring wells and extraction wells. Consultations with Solutions-IES, Inc., have indicated that the injected substrate has reached extraction wells within 1 to 2 weeks of recirculation at other sites where EOS® injection and recirculation were employed.
4. Initiate sustained reduction in contaminant concentrations over time, and reduce contaminant flux from the source area.
5. Promote natural and/or enhanced biodegradation of the residual plume. Several secondary geochemical parameters can be utilized to monitor for anaerobic aquifer conditions such as dissolved oxygen (DO), oxygen-reduction potential (ORP) and pH, These secondary data will be used to determine that anaerobic conditions suitable for reductive dechlorination are sustained within the injection areas.

Dissolved Oxygen. Anaerobic bacteria cannot function at DO concentrations greater than 0.5 mg/L and as a result, reductive dechlorination will not occur (USEPA, 1998). The August 2004 sampling event at the site indicated DO readings averaging below 0.5 mg/L, indicating that anaerobic conditions are present at the site. DO will be measured during baseline and post-injection sampling events.

Oxidation-Reduction Potential. An ORP of less than -50 millivolts (mV) indicates conditions conducive to reductive dechlorination (USEPA, 1998). A majority of the fifty wells sampled during the August 2004 samples indicated ORP values ranging down to -101 mV. ORP will be measured during baseline and post-injection sampling events.

pH. Microorganisms capable of degrading chlorinated solvents prefer a pH between 6 and 8 s.u. (USEPA, 1998). pH measurements at the site during the August 2004 sampling event ranged from 5.4 to 6.3. pH will be measured during baseline and post-injection sampling events.

Total Organic Carbon (TOC. A significant increase in total organic carbon above ambient concentrations (typically less than 20 mg/L) and typically 2 to 3 orders of magnitude above ambient levels indicates the propagation of EOS® in the subsurface. TOC will be measured during baseline and post-injection sampling events.

These parameters are part of routine well development and sampling activities and will be measured along with other MNA parameters and microbial analysis, which will be measured during baseline and post-injection sampling events.

2.3.4 Operation and Maintenance Considerations

The EOS® recirculation effort is a one time operation that will be accomplished using a mobile process trailer, which will be demobilized after the recirculation effort is deemed complete. The mobile process trailer includes all equipment necessary to store, dose, deliver and regulate substrate injection and recirculation. No maintenance is required for the equipment since it will be used temporarily.

The main operational considerations during field implementation are:

1. Establish volumetric flow rates for injection and recirculation.
2. Establish EOS® dosage and dosing control.
3. Ensure spill prevention and containment during recirculation of contaminated groundwater.
4. Continue recirculation until breakthrough of EOS® (appearance of EOS® in extraction wells) is achieved.

Details of implementation of these operational considerations are provided in Section 3.0. After EOS® application has been accomplished, long-term groundwater monitoring will be performed for VOCs and typical MNA parameters as well as occasional microbial analysis as described in more detail in Section 3.0. A long-term groundwater treatment monitoring plan will be developed after the first year of groundwater monitoring following the EOS® recirculation implementation, to detail future monitoring and assessment of subsurface contamination at the site. The plan will also include an evaluation of the need for re-injection of a suitable organic substrate to support ERD.

2.3.5 Land Use Controls

Currently, no specific redevelopment has been planned for the SA 17 area for the immediate future; therefore, no excavations or other intrusive activities that could cause exposure to contaminated soils or groundwater is expected. Future land use is expected to be industrial or commercial.

The SA 17 site is surrounded by an 8-foot high utility fencing and the access gate is locked at all times disallowing site access to non-relevant personnel.

The *Draft Finding of Suitability to Transfer (FOST), McCoy Annex, Early Transfer of OU 2, SA 17 and SA 52, NTC Orlando,* prepared by TetraTechNUS (TtNUS) during April 2005 recommends land use controls on groundwater, soil and existing remediation systems at the site. The following are relevant excerpts from the land use controls recommended in the Draft FOST:

Groundwater Use Controls. The installation of any wells or the extraction or use of groundwater for any purpose other than for groundwater investigation is prohibited without prior written authorization from the Navy and FDEP.

Non-Residential Use Control. Use of the SA 17 Parcel shall be limited to non-residential or industrial uses to include any office or similar use incidental to industrial uses if such incidental use is permitted by FDEP without requiring further environmental remediation beyond that required for industrial use. Prohibited residential uses shall include, but are not limited to, any child or senior adult care, pre-school, or any form of housing.

Remedial Systems Non-interference Controls. Tampering with or damaging groundwater monitoring and/or remediation systems (including pumps, wells, piping, utilities and associated appurtenances) currently located or which may be installed later on the SA 17 Parcel by the Navy will be prohibited. Any adjustments to the systems (such as relocation or realignment) will be made only upon agreement between the Navy and the SA 17 Parcel owner.

Excavation Control. The excavation, drilling or other disturbance of soil within the SA 17 Parcel below a depth of 2 feet bls is prohibited without prior written authorization from the Navy and FDEP. This control is established to prevent direct or indirect contact with potentially-contaminated soil at the top of the water table.

3.0 Overview of Remedial Action

The following subsections provide an overview of the remedial action and post-RA monitoring for site contaminants and natural attenuation parameters at SA 17.

3.1 Enhanced Bioremediation Process Description

The remedial action at SA 17 includes treating the subsurface TCE contamination within the 50-foot by 50-foot source area TTZ-1 with EOS® using a recirculation process where groundwater is withdrawn from one or more wells, blended with EOS® concentrate and re-injected. The implementation of the recirculation process and procurement of the EOS® concentrate will be assigned to Solutions under a subcontract agreement with JVII.

Injection and extraction wells will be installed by a licensed driller under JVII supervision. Additional performance monitoring wells will be installed by the driller, and performance monitoring for VOCs, MNA, and select biological parameters will be conducted by JVII for one year following field implementation of the EOS® injection and recirculation.

Figure 3-1 shows the TTZ-1 layout with locations of the injection, extraction and performance monitoring wells in the source area at SA 17. The mechanism of the enhanced reductive dechlorination process (ERD) using EOS®, and details of the field implementation of the RA, are described in the subsections below.

3.1.1 Electron Donor Selection

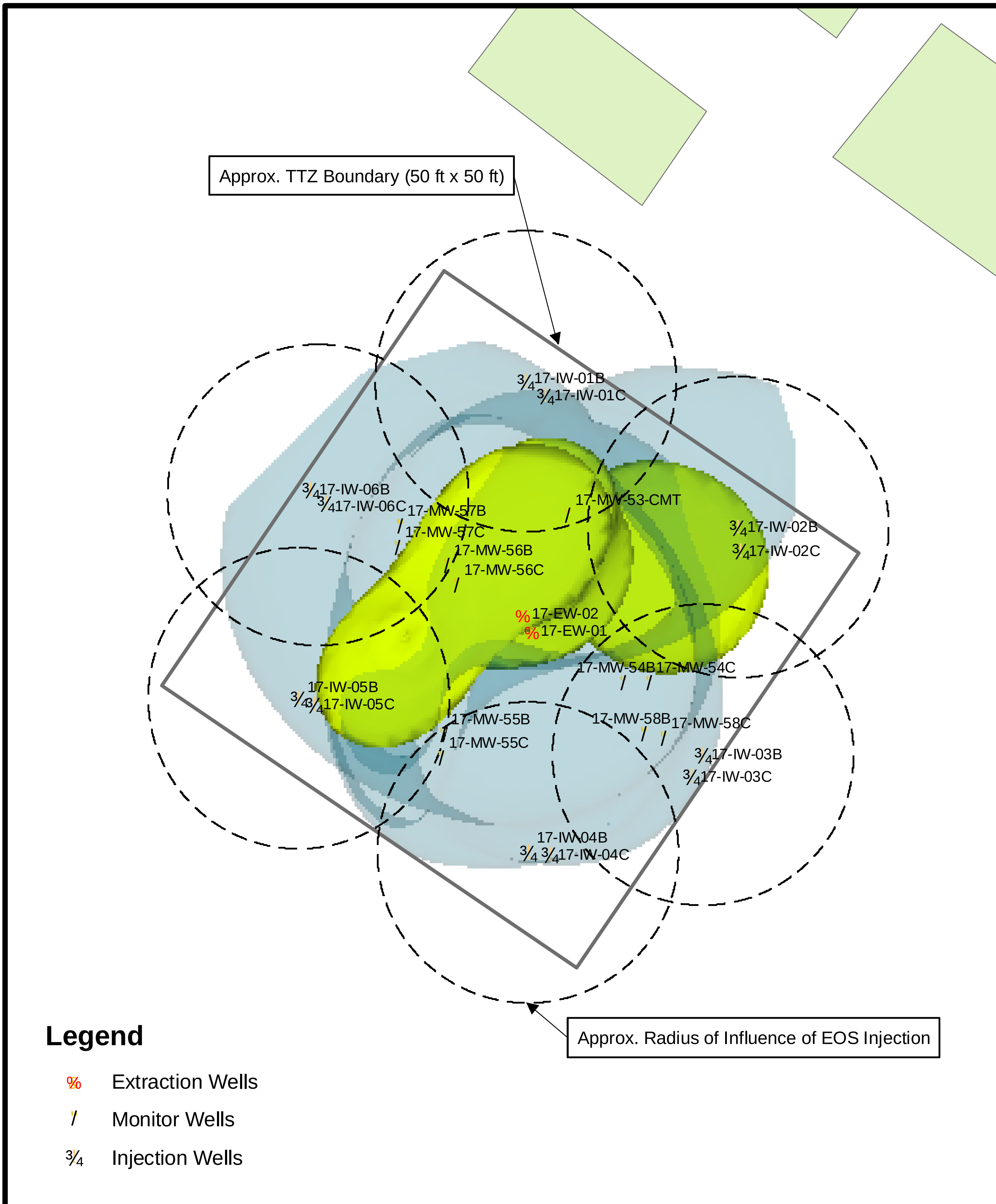
The biotic processes that remediate dissolved halogenated solvents (i.e., TCE) involve a series of oxidation/reduction reactions. The electron donor, EOS®, like many additives used for the enhanced reductive dechlorination of hydrophobic, chlorinated organic carbons, provides a source of electrons that ultimately benefit halorespiring bacteria. These bacteria require anaerobic conditions to metabolize dissolved chlorinated solvents, which are electron acceptors. Thus, EOS® is oxidized, while the chlorinated solvents are sequentially reduced (EOS, 2005). Soybean Oil ($C_{56}H_{100}O_6$), which is similar to EOS®, ferments to acetic acid (CH_3COOH) and hydrogen (H_2) in the equation below:

$$C_{56}H_{100}O_6 \textit{ (soybean oil)} + 50\ H_2O \rightarrow 28\ CH_3COOH \textit{ (acetic acid)} + 44\ H_2$$

Hydrogen and acetic acid then consume electron acceptors (i.e., O_2, NO_3, Fe, SO_4) as well as halogenated solvents such as PCE and TCE, although only hydrogen reduces TCE to ethane.

3.1.2 Reductive Dechlorination Pathway

CVOCs in groundwater can be biologically degraded by naturally occurring microorganisms. When CVOCs are naturally degraded under anaerobic conditions, the process is termed “reductive dechlorination.” The microbes substitute a hydrogen atom for a chlorine atom on the CVOC molecule, thereby reducing the chlorination state of the compound. Addition of a suitable organic substrate such as EOS® to the aquifer can increase the rate of dechlorination by one order of magnitude or more, ultimately producing a non-toxic ethene end-product. This process is called ERD.



CH2MHILL

Figure 3-1
Locations of Injection and Extraction and Monitoring Wells
EOS Recirculation
SA-17, NTC Orlando

ATL \\BOOMER\I\PROJECTS4\NTC ORLANDO SA17\SA17 GIS\SEPT2005_MXD_FILES\FIGURE_3-1.MXD 5/31/2006 D MAGEE

The reductive dechlorination process requires the addition of a degradable organic compound, such as EOS®, into the aquifer to overcome the continuous electron acceptor supply, such as oxygen, nitrates and sulfates that are naturally present. Electron acceptors can enter the contaminated aquifer from upgradient regions or be delivered into the contaminated aquifer through recharge or gaseous oxygen diffusion from the vadose zone. The degradation process initially makes use of the available dissolved oxygen, followed by the nitrates and then the sulfates. Dechlorination of halogenated organic compounds works best under sulfate reducing and methanogenic conditions.

The electron donor EOS® continues to biotically degrade through a fermentation process, which produces molecular hydrogen. Fermenting bacteria work especially well in anaerobic environments. The bacteria gain energy, which is necessary for life, by splitting the organic compounds in EOS® and generating chemically oxidized and reduced compounds.

Finally, dechlorinating bacteria, such as *Dehalococcoides*, derive energy by using the molecular hydrogen as an electron donor and the chlorinated organic compounds as electron acceptors. The microbes substitute the chlorine atoms on the halogenated solvent with the molecular hydrogen in the dehalorespiration process. This results in the sequential chemical reduction of the chlorinated organic compounds eventually yielding harmless byproducts such as ethene and ethane.

3.1.3 Electron Donor Delivery System

The EOS® substrate delivery system using the recirculation process will be implemented using a process trailer which includes pumps, tanks, piping, dosimeter and fittings along with necessary safety appurtenances. Six pairs of injection wells and a pair of extraction wells will be installed to deliver EOS® and recirculate treated groundwater.

3.1.3.1 Injection and Extraction Well Locations

The preliminary step of this RA is to evaluate the available information on aquifer characteristics from previous and recent site investigations, and to determine the placement, depth, diameter, and screen intervals of the injection and extraction wells.

Available aquifer characteristic information such as hydraulic conductivity, horizontal, and vertical gradients and seepage velocities for the three different hydrologic areas (Areas A, B, and C) at SA 17 were provided to Solutions to support their development of the technical approach to the RA for SA 17.

Aquifer pump tests (2-hour and 8-hour) were conducted by JV-II during August 2005 to verify the hydraulic characteristics of the aquifer. The three-dimensional model WINFLOW^{32}®, a numerical groundwater modeling program developed by the U.S. Geological Survey (USGS), was used to estimate the effects of pumping and injection activities from the proposed remediation system. Based on the results of this model run, the number and spacing of injection wells was finalized to provide adequate EOS® dispersion within the subsurface.

3.1.3.2 Aquifer Pump Test and Simulation Modeling

During the design stage, a constant rate 8-hour aquifer pump test was conducted at the site to establish localized hydraulic parameters of the surficial aquifer, which would provide data for a basis to establish preliminary injection and extraction flow rates. A copy of the aquifer pump test report is included in Appendix H and findings from the pump test are summarized below.

An existing monitoring well (OLD-17- 51C) was used to conduct the pump test. This is a 2-inch diameter well screened from 42 feet to 47 feet bls. Eight new 1-inch diameter PVC peizometers were constructed prior to the pump test to be used as monitoring wells at distances of 10 and 20 feet from OLD-17-51C. Four piezometers were screened from 20 to 21 feet bls and the remaining four from 35 to 36 feet bls. Other wells previously constructed were also monitored and have screened intervals in similar depths.

The constant rate pumping test was initiated at OLD-17 -51C (51C) on August 16, 2005. Prior to the constant rate test, background water level data were recorded at several of the monitoring wells for a period of 7 days. A short-term preliminary pumping test (2 hours) was conducted the day before the final constant rate test to establish a sustainable flow rate for the test. The final constant rate pumping test was approximately 8 hours in duration. Flow rates were calculated by recording the time to fill a container of known volume. A flow rate of 5 gpm was sustained for the 8-hour testing period. Water levels were recorded using electronic data loggers (In-Situ Hermit 3000, Minitrolls, or Troll 4000s). Manual water level measurements were recorded as a backup to the electronic data or as a substitute for wells that did not have transducers installed.

To calculate transmissivity and storativity of the aquifer, the water level drawdown data were analyzed using AquiferWin32® pump test analysis software. Two analysis methods were used: Hantush and Jacob (1955), and Neuman (1972). Standard analysis methods such as Cooper and Jacob (1946), Theis Recovery, and Theim Distance Drawdown were not used because of the confined aquifer conditions assumed for each of these methods.

The calculated transmissivities for the surficial aquifer were characteristically low for a sand aquifer. Transmissivities for Zone B and Zone C were similar, with average values of 140 square feet per day (ft^2/day) (1,047 gpd/ft) and 138 ft^2/day, respectively. Assuming an aquifer thickness of 30 feet for Zone B, the hydraulic conductivity was estimated to be 4.7 feet/day. The hydraulic conductivity of Zone C, assuming an aquifer thickness of 20 feet, is approximately 6.9 feet/day. The average storativity of Zones B and C were calculated to be 0.05 and 0.02, respectively.

The results of the aquifer test were incorporated into two separate modeling efforts to provide an indication of the potential aquifer response to the proposed injection and extraction activities at SA 17. The first modeling effort simulated aquifer response to injections at four locations at the four corners of the 50-foot by 50-foot footprint of TTZ-1. The second modeling effort simulated aquifer response to injections at six locations along the circumference of a circle of approximate radius of 23 feet to encompass the TTZ-1 footprint.

3.1.3.3 Stream Line and Particle Tracking Assessment

MODFLOW, a three-dimensional (3-D) numerical groundwater modeling program developed by the U.S. Geological Survey (USGS), was used to estimate the effects of pumping and injection activities from the proposed remediation system.

The draft RAWP proposed injections at four corners of the 50-foot by 50-foot footprint of TTZ-1. After the groundwater flow modeling described below, two additional injection locations were added. Two scenarios were initially modeled with different injection flow rates for the previously-proposed four injection locations, and a third scenario was modeled after adding two more injection locations around TTZ-1.

The model was first calibrated by matching the drawdown effects from the SA 17 aquifer performance test. Five piezometers were used to match the model simulation to observed water levels during the pump test.

The 3-D model was used to simulate the injection of the EOS® into four perimeter 2-inch injection wells located 50 feet apart (at locations previously proposed during preliminary design), with a 4-inch diameter pumping (extraction) well. The model simulations assume continuous operation of the injection and extraction wells. Figure 3-2 shows the locations of the pump test well and piezometers.

The injection rates were simulated for 1 and 3 gpm flow rates. The extraction well was only simulated at a withdrawal rate of 5 gpm. Groundwater drawdown/mounding contours were then generated by the model.

The simulation used the particle tracking method to show the bulk groundwater flow direction each particle would take to reach the extraction well.

Simulation 1 – Four Injection Wells at 4 gpm and Extraction Well at 5 gpm

This simulation incorporated a total injection rate of 4 gpm split between four injection wells and a single extraction well pumping at 5 gpm in the upper layer of the aquifer (Layer 1 encompassing Zones A and B) and the lower layer of the aquifer (Layer 2 encompassing Zone C). The results showed that the travel time for the substrate from all of the 1 gpm injection wells to reach the extraction well in both Layers 1 and 2 occurred in 7 days (168 hours) of continuous operation.

The particle trace plots of both layers for this simulation suggested that an area of aquifer or contamination plume between each injection well may be unaffected by the injection wells at the injection rate of 1 gpm. This indicates that additional wells may need to be installed to provide better coverage of the substrate application and close gaps in substrate distribution between the four injection locations. With an injection rate of 1 gpm, the hydraulic gradient from the extraction well (each at 5 gpm) was shown to be adequate to capture all injected substrate towards the direction of the extraction well. The groundwater velocity vector plots for each layer provide the extent of the impact the extraction well has on the injected substrate. The particle tracking plots are provided in Appendix H.

Simulation 2 – Four Injection Wells at 3 gpm and Extraction Well at 12 gpm

This simulation incorporated a total injection rate of 12 gpm split between four injection wells and a single extraction well pumping at 12 gpm. Both layers have identical remediation systems. The results showed that the travel time for the substrate from all of the 3 gpm injection wells to reach the extraction well in Layer 1 occurred in 20 days (480 hours) of continuous operation and the extraction well went dry. The results showed that the travel time for the substrate from all of the 3 gpm injection wells to reach the extraction well in layer 2 occurred in 4 days (96 hours) of continuous operation. The particle trace plots showed that a majority of the injected substrate (approximately 60 percent) is not captured

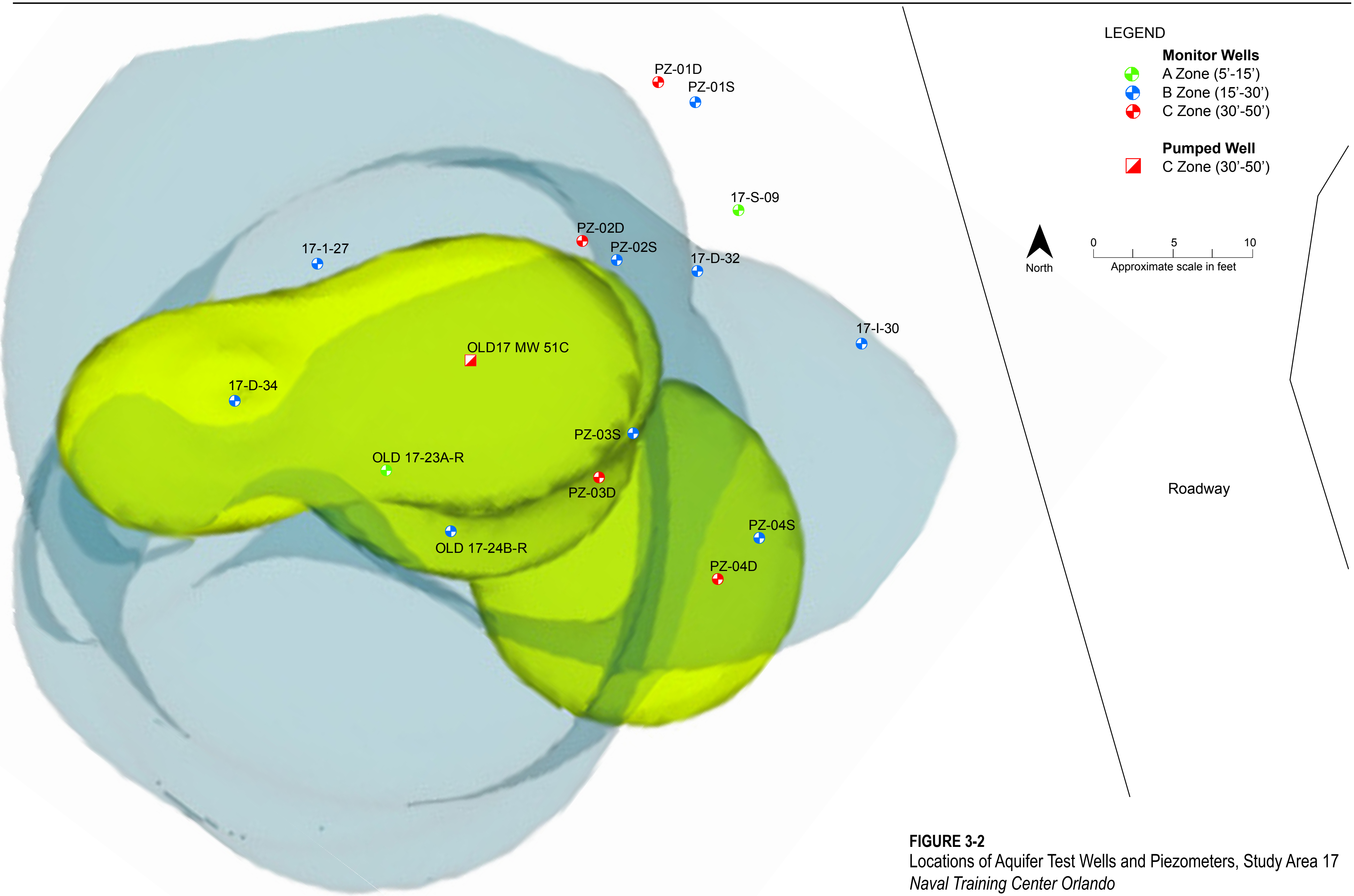


FIGURE 3-2
Locations of Aquifer Test Wells and Piezometers, Study Area 17
Naval Training Center Orlando

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by the extraction well. The groundwater velocity vector plots for each layer show that significant groundwater movement away from the extraction well. The particle tracking plots are provided in Appendix H.

Based on the observations from the first two simulations, the injection well configuration was changed from the four locations previously proposed to six locations placed in a circular configuration around the extraction well, as shown on Figure 3-1. An additional simulation was conducted to account for the new injection well configuration.

Additional information was also obtained from Solutions-IES on the viscosity of EOS®, and calculations were made on the impact of the viscosity on hydraulic conductivity, and the relationship between EOS® dilution rates and the hydraulic conductivity.

An average hydraulic conductivity of 5.6 feet/day was assumed based on the results of the aquifer pump test conducted in 2005. Table 3-1 presents the adjusted hydraulic conductivity (derived from adjustments to the observed hydraulic conductivity) for various dilution rates of EOS®. Appendix H includes calculations used to derive the adjusted hydraulic conductivity presented in Table 3-1.

TABLE 3-1
Kinematic Viscosity and Adjusted SA 17 Hydraulic Conductivity for Various Oil Emulsion Concentrations

Oil Concentration (percent by weight)	Ratio of Kinematic Viscosity of Emulsion to Water	Adjusted Hydraulic Conductivity (feet/day) (including ±20 percent error)
1	1.20	3.84 – 5.76
3	1.30	3.55 – 5.32
5	1.50	3.07 – 4.61
10	1.75	2.63 – 3.95
20	3.0	1.54 – 2.31

Simulation 3 –Injection Wells at 0.5 and 1 gpm, Extraction Wells at 3 and 6 gpm

This MODFLOW model run was conducted to simulate the injection of the emulsified oil substrate into six perimeter injection wells located approximately 25 feet from the extraction well, which is located in the middle of these wells. For the purpose of this model simulation, the aquifer was divided into two layers. The first (top) layer represents Zones A and B, and Layer 2 represents Zone C. The bottom of layer 2 was assumed to be impermeable. Layer 1 extends from 0 to 25 feet bls and layer 2 from 25 to 50 feet bls. The water table was assumed to be at 0 feet to be conservative. A thin layer of semi-confining silty sand separates Zone C from Zones A and B. The model simulation assumed continuous operation of the injection and extraction wells.

After accounting for the higher viscosity of the diluted EOS® solution compared to fresh water, the hydraulic conductivity of both layers of the groundwater flow model was reduced from 5.6 to 2.63 feet/day. This simulation incorporated a total injection rate of 9 gpm split between six injection wells in Layer 1 injecting at 0.5 gpm each (for a total injection rate of 3 gpm), and 6 injection wells injecting at 1 gpm each in Layer 2 (for a total injection rate of 6 gpm). The extraction well in Layer 1 pumped at 3 gpm, the extraction well in Layer 2 pumped at 6 gpm, to match the respective injection flow rates.

The extraction and injection rate inputs were reduced to 3 gpm in Layer 1 because at a flow rate of 6 gpm and the lower hydraulic conductivity, the model simulation showed the water table dropping below the bottom of Layer 1 near the extraction well. The particle tracking plots are provided in Appendix H.

Summary and Conclusion from Groundwater Flow Modeling

With a total extraction rate of 9 gpm, the hydraulic gradient from the extraction wells remains adequate to capture all injected substrate towards the direction of the extraction wells. The Zone C aquifer (Layer 2) is able to support an extraction rate of 6 gpm without going dry, but with increased drawdown due to the viscosity effects on the hydraulic conductivity. Therefore, an estimated starting flow rate for the Layer 1 injection and extraction wells should be 3 gpm (0.5 gpm in each of the six injection wells, 3 gpm in the extraction well) and 6 gpm for Layer 2 wells (1 gpm in each of the six injection wells and 6 gpm in the extraction well). Field observations of water levels in existing wells within the TTZ-1 should be monitored for mounding and drawdown to verify and adjust flow rates accordingly.

3.1.3.4 Electron Donor Quantity

The proposed schematic of the EOS® delivery system was designed by Solutions using site-specific parameters for SA 17. Design parameters included in determining the parameters of the delivery system were subsurface contaminant concentrations, soil characteristics, hydraulic characteristics, treatment area dimensions, hydrogen demand at the site, and the design lifespan. A software program designed by EOS Remediation, Inc. was used by Solutions to then calculate the total quantity of EOS® required to treat the contaminant mass present at the site. Based on the site-specific input parameters, a total of 20 drums of EOS® was estimated by Solutions to meet the requirements of the hydrogen demand and soil adsorptive capacity at SA 17. A copy of the worksheet used by Solutions to arrive at the total EOS® quantity required for SA 17 is included in Appendix F.

3.1.3.5 Injection and Extraction Well Layout

The injection well spacing was designed based on the objective of attempting to smear the subsurface within the TTZ-1 area as evenly as possible with EOS®. Based on a historic radius of influence of 15to 20 feet achieved by EOS® injections performed by Solutions in silty sands (representative of TTZ-1 at SA 17), it was deemed that sufficient coverage would be provided by placing six pairs of injection wells to encompass the 50-foot by 50-foot footprint of TTZ-1, as shown on Figure 3-1.

Based on comments received from the Navy on the Draft RAWP for SA 17, an additional evaluation of historical MIP investigation data was conducted to better identify the target treatment intervals within which to inject EOS® into the subsurface. Data collected from the MIP investigations were input into the Environmental Visualization System (EVS) program to generate three-dimensional representations of the subsurface contaminant mass.

Figures 3-3 and 3-4 present a plan and cross-sectional view of the modeled subsurface contaminant concentrations. Three vertical cross-sectional slices running between diametrically oppose injection locations were examined. Cross-section B-B′ was selected to be the most representative for the purpose of selecting the injection well screen intervals.

As depicted on Figure 3-4, which shows CVOC concentrations after filtering the model for soil conductivity readings, elevated CVOC concentrations appear to be present mostly between 15 to 25 feet bls and 30 to 40 feet bls. EOS® injections are expected to impact the subsurface contamination in these more permeable sandy layers. Based on this evaluation, the target treatment intervals selected for EOS® injection are 15 to 25 feet bls and 30 to 40 feet bls.

To assist the lateral migration of EOS® within these areas, two injection wells will be installed at each of six locations around the perimeter of TTZ-1, as shown on Figure 3-1. A shallow 2-inch diameter injection well screened between 15 and 25 feet bls (in Zone B) and a deep injection well screened between 30 and 40 feet bls (in Zone C) will be used to deliver the EOS® into the subsurface. A pair of 4-inch extraction wells will be installed in the middle of TTZ-1, with the shallow extraction well screened between 15 and 25 feet bls and the deep extraction well screened between 30 and 40 feet bls.

3.1.3.6 Aboveground Process Control and Recirculation Methodology

To achieve an optimum balance in the recirculation process and propagation of the EOS® as uniformly as possible through the subsurface, aboveground process control will be achieved by using a dosimeter, valves, pressure regulators, and pressure and flow indicators installed inline on the EOS® feed and extraction lines and on wellheads as needed. Figure 3-5 shows a process and instrumentation diagram (PID) of the EOS® delivery process as proposed by Solutions.

The recirculation sequence will be initiated with extraction of groundwater from the recovery wells into a storage tank. This will create a drawdown near the extraction wells. The temporary gradient change caused by the extraction is expected to aid in better distribution of the EOS® in the TTZ. The stored water will be injected into the injection wells after being dosed with the EOS®. The following detailed steps are involved in the recirculation process.

Step 1: Groundwater Recovery

Each extraction well will be outfitted with pressure transducer wired to the pump controller. The pressure transducer will regulate the water level in the well during pumping to provide a nearly constant drawdown.

The pump discharge will be piped to a 21,000-gallon frac tank using flexible hose or pipe contained within a larger PVC pipe that will act as secondary containment. The water level in the frac tank will be controlled with a float switch connected to each pump controller. The float switch will turn off the pump inside the extraction well when the frac tank has filled. In the event of a malfunction of the float switch, the secondary containment piping will route tank overflow back to each extraction well. Each overflow pipe will also be outfitted with a moisture sensing switch routed to the pump controller to turn the pump off if moisture is detected in the overflow pipe.

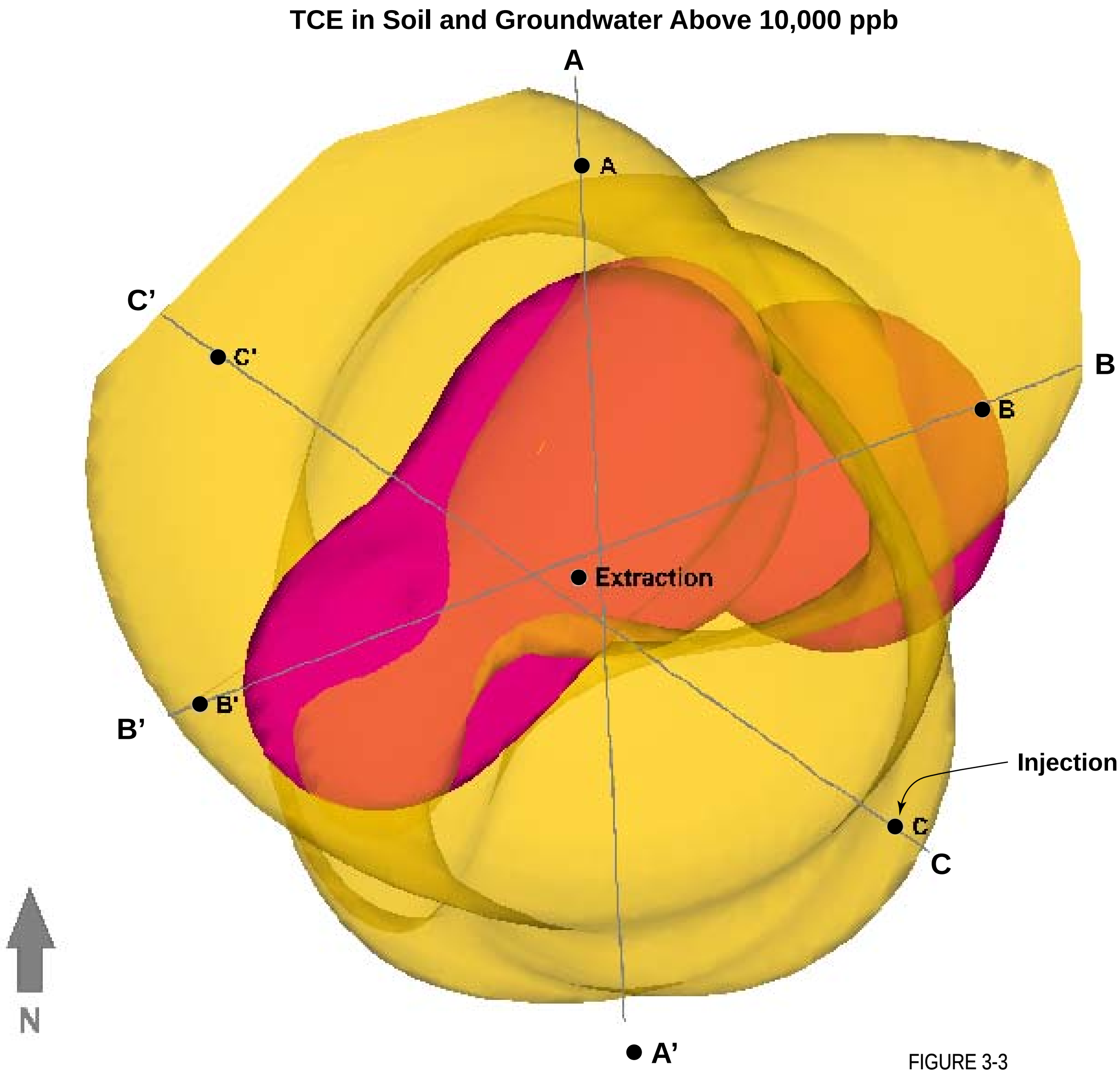

FIGURE 3-3
Plan View of Modeled Contaminant Plume
Study Area 17, *NTC Orlando*

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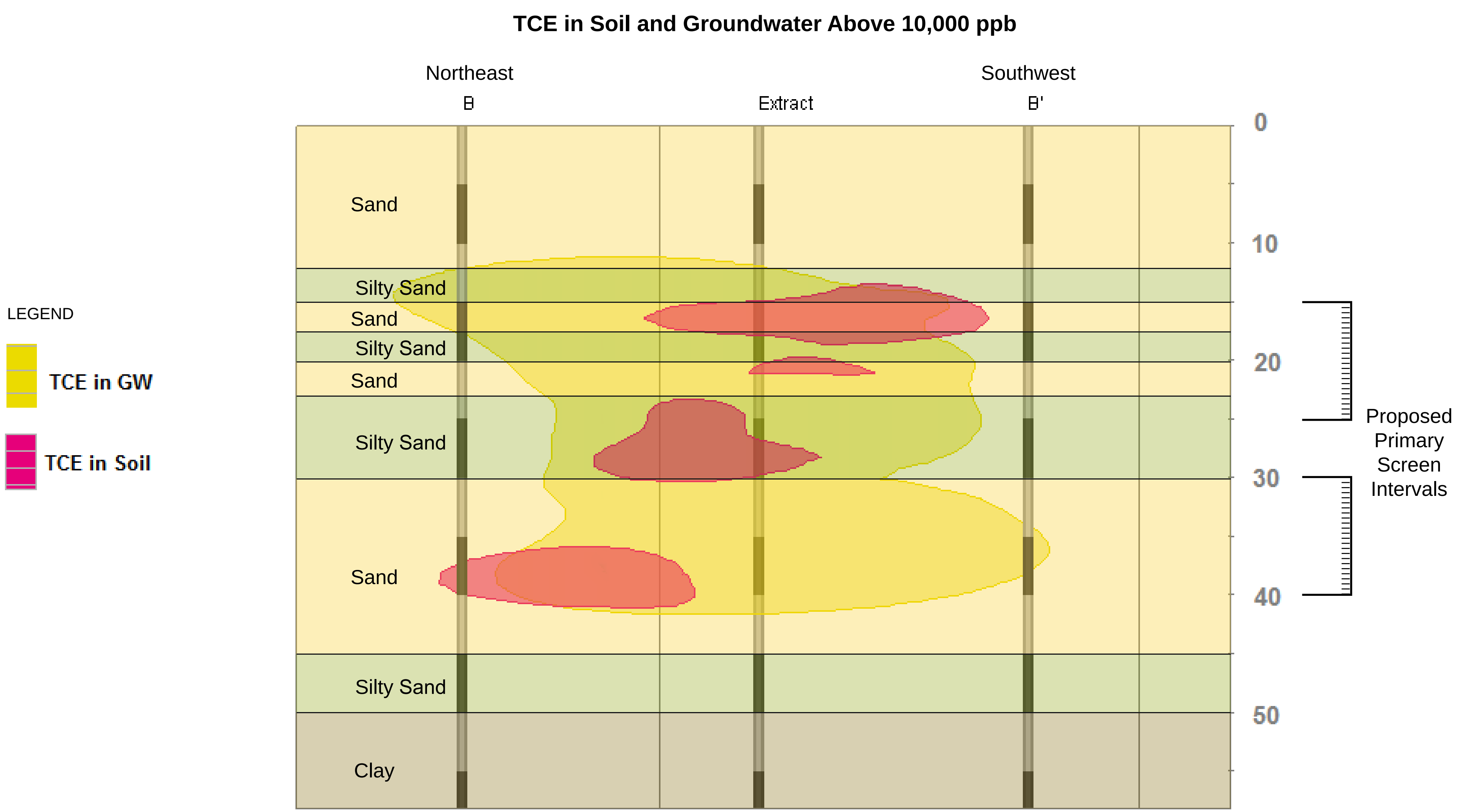

FIGURE 3-4
Proposed Injection and Extraction Well Screen Intervals
Study Area 17, NTC Orlando

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The pumps and equipment will be powered with a portable generator. The pump controller can be adjusted in the field for multiple sensor and switch inputs.

Step 2: EOS® Dosing of Extracted Groundwater and Injection

Two submersible pumps located within the frac tank will pump the recovered groundwater for the injection. The injection will be initiated with dilute EOS®, and after the required quantity of EOS® has been injected, the injection will continue with the remaining recovered groundwater.

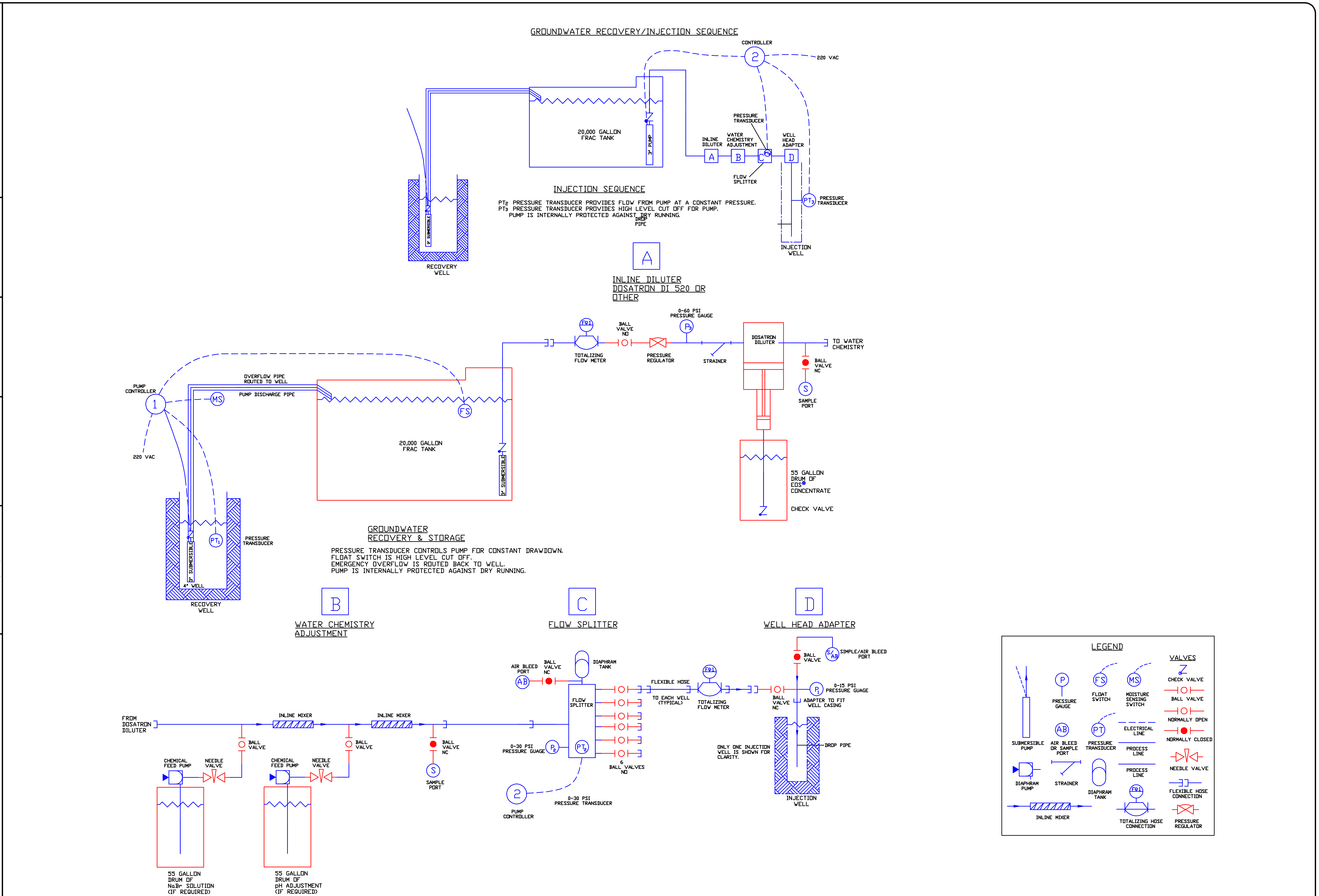
Four components will be located in the injection line: 1) inline dosimeter (Dosatron®), 2) water chemistry amendment unit, 3) flow splitter, and 4) well head adapter. Each of these is described below.

Inline Diluter. (see insert A on Figure 3-5). The EOS® concentrate is diluted with groundwater using an inline diluter such as the DI520 manufactured by Dosatron International. The dosimeter unit is installed directly inline with the water supply. The dosimeter operates without electricity, using the in-line water pressure as the energy source. The water pressure activates the Dosatron, causing a suction pressure necessary to take up the required percentage of EOS® concentrate directly from a 55-gallon drum connected to the dosimeter. Inside the Dosatron, the EOS concentrate is mixed with the water and the water pressure forces the solution downstream. The amount of EOS® concentrate delivered for mixing is directly proportional to the volume of water entering the Dosatron, regardless of variations in flow or pressure that may occur in the main water supply line. This ensures a constant dilution rate. The dilution percentage can be set from 5 to 20 percent for the Dosatron DI520. Also included with the dosimeter unit is an integral pressure regulator, a 200-mesh strainer to remove fines and a ball valve to control flow. A totalizing flow meter will be attached to the input side of the dosimeter to record the volume of water pumped. The discharge side of the Dosatron will be plumbed to the water chemistry unit.

The Water Chemistry Unit. (see insert B in Figure 3-5) This unit contains between one and three chemical feed pumps that are used to amend the water chemistry. The first feed pump will be used to introduce a sodium bromide solution into the injectate. Because the pH of groundwater at the site is slightly acidic, sodium bicarbonate will be added. Approximately 250 pounds of sodium bicarbonate (total quantity) will be added using a second feed pump to regulate the pH with the addition of a buffering compound.

The feed pumps have a variable pumping capacity and will be outfitted with a needle valve to control flow. Inline mixers are provided downstream of each feed pump. A sampling port will be provided to collect samples for field analysis of pH.

Flow Splitter. (see insert C in Figure 3-5). The output from the water chemistry unit will flow into a flow splitter. The flow splitter will consist of a small tank outfitted with a bladder diaphragm tank, pressure gauge, pressure transducer and six valved outlets. Each of the outlets will be connected to an injection well through a flexible hose. A pressure transducer inserted into the splitter will be wired to the pump controller to vary the pump output to provide a nearly constant pressure from the tank.



PROJECT NUMBER 2660.05A3.CH2M

DRAFTER RT

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PROJECT MANAGER WB

DATE 03/14/06

FILE FIGURE 1.DWG

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PROCESS AND INSTRUMENTATION
STUDY AREA 17 (SA-17) PILOT TEST
NAVAL TRAINING CENTER
ORLANDO, FL

FIGURE 3-5

Well Head Adapter. (see insert D in Figure 3-5). The well head adapter will consist of a PVC tee connected to the injection well using a Fernco® coupling or other fitting adaptable to pipe threads. The well head adapter will be outfitted with a totalizing flow meter, pressure gauge, ball valve and bleed port. The flow meter will be used to record the total volume of injectate and for estimation of instantaneous flow rate by timing the meter. The ball valve

can be used to close off the well after the required volume of injectate has been injected. The pressure gauge will allow estimation of approximate injection pressure. The bleed port will allow periodic sampling of the injectate for baseline sampling required to establish the concentration of Polysorbate 80 being introduced into the subsurface. The bleed port also provides a means of removing air from the well head adapter. At least one well will be outfitted with a pressure transducer to monitor injection pressures within the well. The transducer output will be connected to the pump controller operated as a high level cut off.

Step 3: Evaluation of Travel Time from Injection Well to Extraction Well

As indicated in Section 3.1.3.2 above, the viscosity of the EOS® injectate is expected to affect the hydraulic conductivity and therefore travel times between the injection well and the extraction well. Based on observations from other EOS® injections at other sites by Solutions, injection of a 10 percent solution of EOS® (1 part EOS to 10 parts water) will first be attempted. Three pairs of intermediate sentry wells (17-MW 56B, 17-MW-56C, 17-MW-57B, 17-MW-57C, 17-MW-58B and 17-MW-58B) will be installed at distances of 8 feet and 16 feet from two injection well pairs, as shown on Figure 3-1. Each pair of sentry wells will be installed to the same depths as the injection and extraction wells, with one well in each pair screened between 15 to 20 feet bls and the other well screened between 30 to 40 feet bls.

After injection of the EOS® is initiated, these sentry wells will be monitored for the appearance of EOS® and the sodium bromide tracer.

3.1.4 Field Implementation Performance Goals

3.1.4.1 Achievement of EOS® Breakthrough and Recirculation

The first indication of EOS® migration from the injection wells towards the extraction well will be in the intermediate sentry wells 17-MW-57B and 17-MW-57C (shown in Figure 3-1). Groundwater samples collected periodically from these wells will be checked for the presence of sodium bromide tracer previously added to the injectate using a Hach® selective ion electrode for bromine. Once the tracer has been detected in the groundwater sample, a field test kit such as a Hach® TOC Reagent Set #2760445 -High Range, or equivalent) will be used to measure TOC concentrations for comparison to the baseline TOC concentrations, in order to verify the presence of EOS® in the sentry wells. Based on an evaluation of the travel time of the EOS® solution from the injection well to the first pair of sentry wells, similar verification will be conducted in the other two pairs of sentry wells (17-MW-56B, 17-MW-56C, 17-MW-58B and 17-MW-58C) and finally, in extraction wells 17-EW-01 and 17-EW-02.

Recirculation of extracted groundwater will continue until breakthrough as described above has occurred as confirmed by the presence of EOS® in the extraction wells. This breakthrough is the performance goal for the recirculation effort and will represent successful completion of the field implementation of the RA. After breakthrough is confirmed, the recirculation will continue for 2 to 3 days before being stopped, and the equipment will be decontaminated and demobilized from the site.

3.1.4.2 Near-term Changes in Geochemistry and Microbial Populations

Another performance goal of this RA is to create geochemical conditions conducive to the ERD process as described in Section 2.3.3. Monitoring and evaluation of trends in DO, ORP, pH, TOC and the presence of *Dehalococcoides* microbes are near-term (1 to 6 months) and long-term performance goals for this RA. The Sampling and Analysis Plan in Section 5.0 presents the target parameters for baseline and performance monitoring which include the above metrics.

Based on previous site investigations conducted at the site, conditions conducive to ERD are present at the site and natural attenuation is an ongoing process at this site as described in Section 2.1.5 and 2.3.3.

3.1.5 Performance Monitoring Overview

Prior to the EOS® injection effort, baseline sampling for CVOCs, MNA parameters and microbial analysis will be conducted in ten monitoring wells installed within the immediate vicinity of the treated source area, for the purposes of performance monitoring. The locations of these monitoring wells are shown in Figure 3-1. The monitoring wells are screened within Zones B and C, and their construction is described in more detail in Section 4.0. Additional details of the sampling scheme are presented in Table 5-3, Section 5.0 Sampling and Analysis Plan.

Subsequent to the EOS® injection and recirculation effort, quarterly performance monitoring of the groundwater will be conducted at these wells to study the treatment effectiveness of the bioremediation effort.

In order to satisfy the zone of discharge (ZOD) variance requirements, FDEP has indicated that for sites which use EOS®, monitoring of EOS® constituents namely total recoverable petroleum hydrocarbons (TRPH) and Polysorbate 80, will be required. Polysorbate 80 is not a typical target parameter with a U.S. Environmental Protection Agency (EPA)- approved laboratory method. Based on the FDEP acceptance letter for EOS® dated May 20, 2005, the drinking water analysis method SM5540D for foaming agents has been identified as the preferred method of laboratory analysis for Polysorbate 80. Additionally, as part of the requirements of Rule 62-522,300(3)(c) of the Florida Administrative Code (FAC), FDEP has indicated that sodium, chloride, bromide, total dissolved solids and pH be added to the list of parameters monitored during performance monitoring. Accordingly, these parameters have been added to the performance monitoring list.

Additional information on permitting requirements is included in Section 5.2.
During the first year of performance monitoring, quarterly groundwater monitoring reports will be written to summarize the effectiveness of the bioremediation effort, and recommendations for future action for TTZ-1 and the dissolved plume downgradient of TTZ-1 will be provided in these reports as necessary.

3.2 Monitored Natural Attenuation

Natural attenuation monitoring has been planned for several years after this RA. The total duration of this monitoring will be determined based on the contaminant reduction and geochemical conditions prevailing at the site. MNA parameters to be analyzed for during baseline and quarterly performance monitoring sampling are detailed in Section 5.0 Sampling and Analysis Plan. The frequency of sampling events will be quarterly for the first year and re-evaluated after the first year for continued sampling in the future.

4.0 Remedial Action Construction

This section describes the scope of work and project schedule; regulatory framework; detailed descriptions of pre-construction activities, approach to construction, startup and operation of EOS® of injection/recirculation/extraction system; and reporting requirements.

4.1 Scope of Work

The Scope of work for this RA is involves furnishing all labor, equipment, materials, and supplies necessary to install injection, extraction and groundwater monitoring wells, and conduct EOS® injection, groundwater extraction and recirculation operations followed by treatment performance monitoring at SA 17. The following subsections describe the various work elements associated with the performance of the scope of work.

4.2 Pre-construction Permits and Submittals

Prior to commencement of field work, necessary dig permits will be secured to ensure that all known underground utilities are marked.

Based on information from the U.S Fish and Wildlife Service's North Florida office, and site background information, there are no endangered species known to be present in areas that will be disturbed by construction activities at SA 17.

No permits are required prior to installation of monitoring and extraction wells. For injection wells, applicable Underground Injection Control (UIC) regulations are listed at Rule 62-528, FAC (Underground Injection Control); specifically, Part V – Criteria and Standards for Class V Wells and Part VI – Class V Well Permitting.

In a letter dated May 20, 2005 from Mr. Rick Ruscito, P.E. and Rebecca Lockenbach of the Bureau of Petroleum Storage Systems, FDEP, to Mr. Gary Birk of EOS Remediation, Inc., the agency and regulatory requirements for performing EOS® injections at remediation sites were outlined. The letter states that "the issuance of a site-specific remedial action plan approval order by the FDEP, for remediation via injection of EOS® into an aquifer, constitutes the granting of the state's permit for a Class V Injection Well."

In addition, for FDEP acceptance of the use of EOS® as a product for in-situ anaerobic bioremediation and the allowance of a zone of discharge by Rule 62-522.300(2)(c) F.A.C, the following conditions need to be addressed in a Remedial Action Work Plan which has to be accepted by FDEP:

- Identification of the chemical species contained in EOS® that will be introduced into the subsurface via the injection well, namely Polysorbate 80, TRPH, sodium, total dissolved solids, chloride (if significant amounts of this degradation byproduct will be generated) and bromide (if a tracer is being used). For this RA, sodium bromide tracer will be used.

Therefore, bromide will also be included in the list of groundwater parameters to be monitored.

- Indication of the size and duration of the temporary ZOD of EOS® . For this RA at SA 17, the size of the ZOD will be an area 50 feet wide and 50 feet long, to a depth of approximately 50 feet bls. The actual duration of the EOS® discharge into the aquifer is expected to be approximately 21 days.
- Address groundwater monitoring of these parameters before and after injection. The ZOD will be monitored prior to introduction of EOS® into the aquifer as part of a baseline sampling and analysis event, and monitored initially on a quarterly basis for a year after EOS® injections. The parameters named in a) above will be included in a more extensive list of groundwater parameters which will be analyzed at an offsite laboratory.

Additionally, this letter stipulates that the injection of EOS® will be performed in such a manner the no undesirable migration of either the product's ingredients or the contaminants already in the aquifer results. The low flow rate of injection and extraction at SA 17 is not expected to cause migration of either EOS® or CVOCs already present in the TTZ-1.

Prior to mobilization to the site, all subcontractors will be required to submit to JVII, all relevant health and safety plans, activity hazard analyses, certifications and licenses required to perform the scope of work as detailed in this work plan.

4.3 Mobilization and Setup of Temporary Facilities, Utilities and Site Controls

This task will consist of mobilizing personnel and equipment to the work site and establishing temporary facilities. The temporary facilities will include portable sanitary facilities, a decontamination area, a site support area, and equipment lay down area. It is anticipated that project management and scheduling activities, including contractor coordination, will be achieved from the JV-II office ("the warehouse") located at NTC Orlando, which is equipped with telephone and facsimile capabilities. Office supplies, field equipment, and PPE will be stored in this office.

Prior to the commencement of any well installation activities, JV-II will conduct a utility clearance survey and prepare the well installation locations, decontamination area, site support area, and equipment laydown area. The well installation areas at the work site will be marked with paint and stakes, as appropriate; and an underground utility survey will be conducted. Utilities that intersect an excavation area will be physically verified. All marked utility lines in areas of excavation activities conducted with machinery will be continuously monitored for signs of buried objects. No excavation or trenching is anticipated in the course of site work activities at SA 17.

Any damage caused to underground utilities or subsurface structures during intrusive activities will be immediately reported to the Navy Technical Representative (NTR) and subsequently repaired by JV-II via methods approved by the NTR.

No permanent power is available near SA 17 and will not be installed for this effort. Power supply will be provided via a generator, and a fuel tank will be placed to provide fuel for the generator. There is a fire hydrant nearby for water supply and will be utilized. The necessary backflow preventer for using the fire hydrant will be provided by Solutions, and prior permission for using the fire hydrant will be obtained by JVII from the City of Orlando.

Although earthwork (soil removal, backfill, and grading) is not anticipated at the project site, erosion control measures will be applied during site activities to protect a drainage swale located south of the work area. The controls will consist of silt fences and hay bales, which will be installed as outlined in Section 5.0, Environmental Protection Plan (included in this Work Plan).

Figure 4-1 shows the general site layout.

4.3.1 Abandoning of Old ISCO Injector Wells

Several injector wells used to conduct the insitu chemical oxidation (ISCO) treatment in 2000 and 2001 still exist at the site within the footprint of the TTZ-1. These wells will hinder installation of proposed injection, extraction and monitoring wells at the site. The wells are constructed of 1.25-inch diameter galvanized iron pipe, each with a 3-foot stainless steel screen.

The well depths for grouting range from approximately 13 feet bls to 30 feet bls. Approximate numbers and depths of wells to be abandoned are as follows :

- 3 wells with depths of 10 to 13 feet bls
- 3 wells to approximately 20 feet bls
- 8 wells to approximately 25 feet bls
- 9 wells to approximately 30 feet bls

The well abandonings will be performed by a qualified well driller licensed by the State of Florida using methods accepted by the State of Florida. The wells will be grouted up to 23 feet from bottom to the land surface with Portland cement/bentonite (powdered) grout slurry, using a pressure/tremie pipe method for placing the grout. Prior to beginning grouting operations, the total depth of each well to be abandoned will be verified by sounding. Wellheads will be rechecked for settling after grouting, and will be topped off with grout as necessary.

The well abandoning subcontractor (driller) will be required to excavate around each well riser to a depth of at least 6 inches below existing grade, after first breaking up and removing any concrete slab or old grout present around the well casing at the land surface. The galvanized well casing will be cut off at least 6 inches below grade using an electric reciprocating saw, cutting torch, or equivalent technology. After the casing has been grouted, native soils will be placed over the well to grade.

The well abandoning subcontractor will complete and submit any permits or notifications required by appropriate regulatory agencies for well drilling and abandoning in Orlando, Florida.

Legend

Ground Water Wells

- DPT Loactions
- Injector Wells
- Monitoring Wells

N

0 6 12 18 24 Feet

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Figure 4-1
Site Layout
SA-17, NTC Orlando

\\Boomer\I\projects4\NTC Orlando SA17\SA17 GIS\Sept2005_MXD_Files\Figure_2.1.mxd Edit Date: 3/24/2006 Editor: D. Magee

The well abandoning subcontractor will install a temporary decontamination pad designed to collect solids and liquids produced during decontamination of drilling equipment. Upon completion of the drilling work, the decontamination pad will be removed and wastes will be collected and contained as described in Section 6.0 Waste Management.

The well abandoning subcontractor will decontaminate the drill rig, pipes, bits, tools, and all down-hole equipment. Decontamination shall consist of high pressure, low-volume steam cleaning at the temporary decontamination pad.

4.4 Site Surveying

Prior to the beginning of intrusive activities, a survey will be conducted to establish temporary bench marks and other control points around the site, and to establish the boundaries encompassing the injection and extraction well locations. This boundary represents the estimated groundwater contamination source area boundary. The survey will be conducted by a Professional Surveyor registered in the State of Florida.

The center points of the injection, monitoring and extraction wells will be located in the field using a Global Positioning System (GPS) receiver, and marked to assist the well driller, prior to well installations. The coordinates of the center points of the wells will be derived from the Environmental Geographic Information System (EGIS) prepared for SA 17. The well location will be surveyed again after installation.

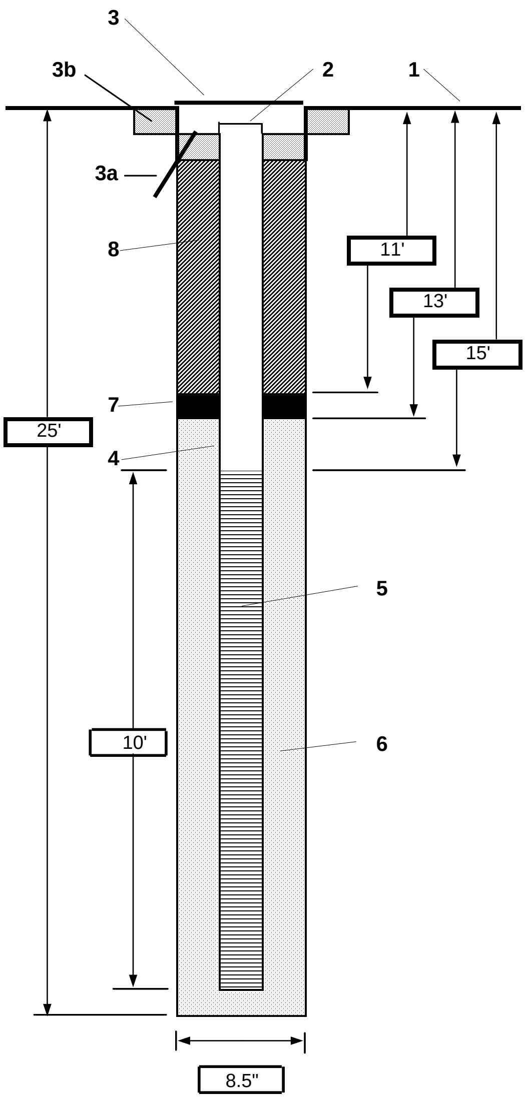
4.5 Installation of Monitoring, Injection, and Extraction Wells

All wells will be installed and developed by a well driller licensed in the State of Florida. Figure 3-1 shows the locations of the injection, extraction and monitoring wells to be installed at SA 17. Figures 4-2, 4-3, 4-4 and 4-5 show typical injection and extraction well construction diagrams. The monitoring wells will be constructed similar to injection wells, with the exception that they will have 5-foot screen lengths, while the injection wells will have 10-foot screen lengths.

4.5.1 Drilling Method

Drill rig operations will be conducted by a driller licensed in the State of Florida. The wells will be installed using rotasonic drilling methods. The wells will be installed as straight and plumb as practicable.

Figure 4-2 Typical Shallow Injection Well Construction, Study Area 17, NTC Orlando



1- Ground elevation at well: TBD

2- Top of casing elevation: TBD

3- Wellhead protection cover type: Steel 8 inch water valve cover
   a) drain tube?
   b) concrete pad dimensions: 2' x 2' x 6"

4- Dia./type of well casing: 2 Inch Schedule 40 flush-threaded PVC,

5- Type/slot size of screen: PVC Vee-Wire continuous slot 0.010"

6- Type screen filter: 20/30 Silica
   a) Quantity used

7- Type of seal: Bentonite chips, 3/8"
   a) Quantity used

8- Grout
   a) Grout mix used: Type II Portland cement
   b) Method of placement: Tremie /pressure
   c) Vol. of well casing grout

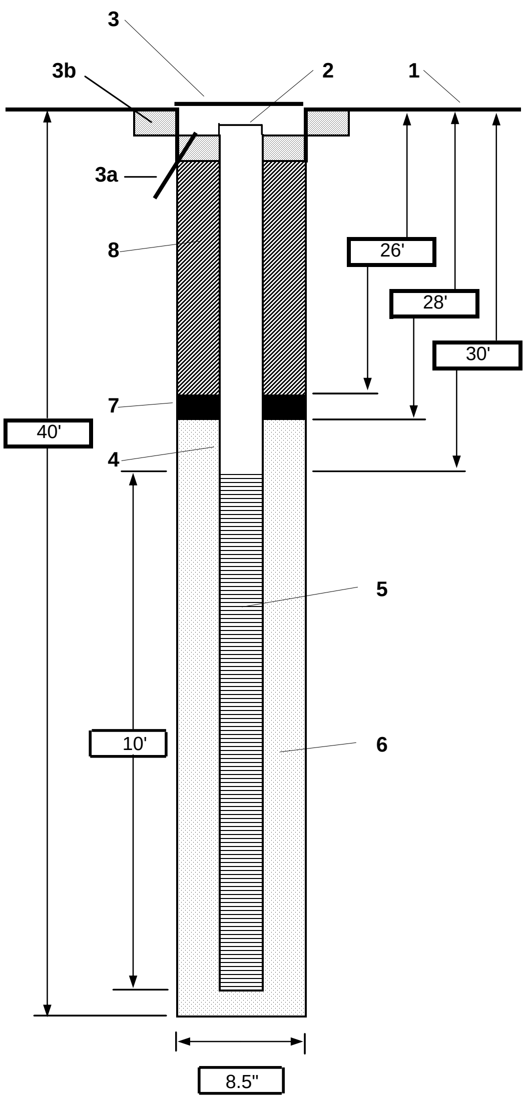
Development method: Submersible pump

Development time

Estimated purge volume

Comments
Wellhead is equipped with 2" male Camlock fitting

Figure 4-3 Typical Deep Injection Well Construction, Study Area 17, NTC Orlando

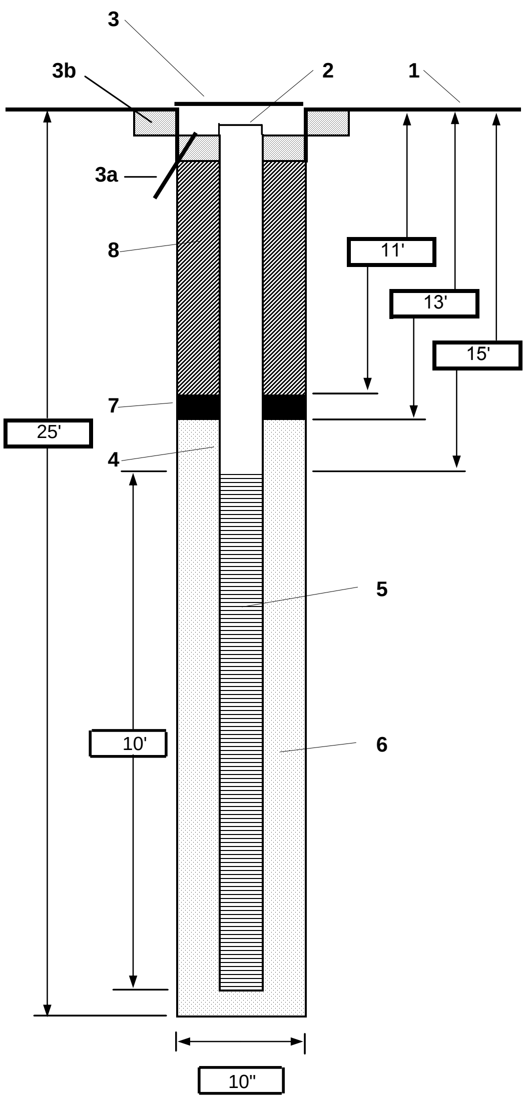


1- Ground elevation at well	TBD
2- Top of casing elevation	TBD
3- Wellhead protection cover type	Steel 8 inch water valve cover
a) drain tube?	
b) concrete pad dimensions	2' x 2' x 6"
4- Dia./type of well casing	2 Inch Schedule 40 flush-threaded PVC,
5- Type/slot size of screen	PVC Vee-Wire continuous slot 0.010"
6- Type screen filter	20/30 Silica
a) Quantity used	
7- Type of seal	Bentonite chips, 3/8"
a) Quantity used	
8- Grout	
a) Grout mix used	Type II Portland cement
b) Method of placement	Tremie /pressure
c) Vol. of well casing grout	
Development method	Submersible pump
Development time	
Estimated purge volume	

Comments

Wellhead is equipped with 2" male Camlock fitting

Figure 4-4 Typical Shallow Extraction Well Construction, Study Area 17, NTC Orlando



1- Ground elevation at well	TBD
2- Top of casing elevation	TBD
3- Wellhead protection cover type	Steel 8 inch water valve cover
a) drain tube?	
b) concrete pad dimensions	2' x 2' x 6"
4- Dia./type of well casing	4 Inch Schedule 40 flush-threaded PVC,
5- Type/slot size of screen	PVC Vee-Wire continuous slot 0.010"
6- Type screen filter	20/30 Silica
a) Quantity used	
7- Type of seal	Bentonite chips, 3/8"
a) Quantity used	
8- Grout	
a) Grout mix used	Type II Portland cement
b) Method of placement	Tremie /pressure
c) Vol. of well casing grout	
Development method	Submersible pump
Development time	
Estimated purge volume	
Comments	Wellhead is equipped with threaded collar

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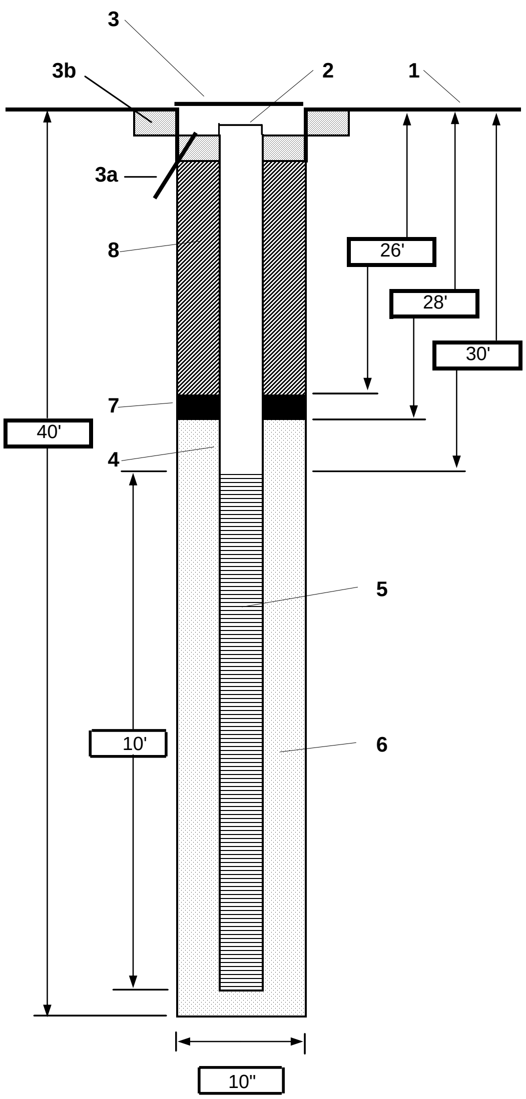
Figure 4-5 Typical Deep Extraction Well Construction, Study Area 17, NTC Orlando



1- Ground elevation at well	TBD
2- Top of casing elevation	TBD
3- Wellhead protection cover type	Steel 8 inch water valve cover
a) drain tube?	
b) concrete pad dimensions	2' x 2' x 6"
4- Dia./type of well casing	4 Inch Schedule 40 flush-threaded PVC,
5- Type/slot size of screen	PVC Vee-Wire continuous slot 0.010"
6- Type screen filter	20/30 Silica
a) Quantity used	
7- Type of seal	Bentonite chips, 3/8"
a) Quantity used	
8- Grout	
a) Grout mix used	Type II Portland cement
b) Method of placement	Tremie /pressure
c) Vol. of well casing grout	
Development method	Submersible pump
Development time	
Estimated purge volume	

Comments

Wellhead is equipped with threaded collar

The driller will contain all cuttings, water, and drill mud in 55-gallon steel drums. JV-II will sample and dispose of the waste. The subcontractor will supply and be responsible for labeling the investigative derived waste (IDW) drums.

4.5.2 Casing and Screen

Injection and Monitoring Wells

Each injection and monitoring well will be constructed of 2-inch inside diameter flush-threaded, Schedule 40 polyvinyl chloride (PVC) solid riser and 0.020-inch factory-slotted well screen with a silt trap style threaded well bottom cap. The injections wells will be constructed with a Johnson Vee-Wire continuous wrapped screen, constructed of Schedule 40 PVC.

The shallow injection wells will be installed within Zone B, with screen intervals between 15 and 25 feet bls. No wells screened within only Zone A have been proposed due to the small saturated thickness of Zone A (roughly 5 feet in thickness with the water table ranging from 2.5 to 5 feet bls), as well as the possibility of dewatering being caused in this zone during the groundwater extraction process. The deep injection wells will be installed within 5 feet away from the shallow injection wells and are being proposed to have 10-foot screens with screen intervals from 30 to 40 feet bls within Zone C.

The monitoring wells will be installed within Zones B and C with 5-foot screen intervals at locations indicated on Figure 3-1. Within Zone B, the monitoring wells will be screened approximately between 20 and 25 feet. Within Zone C, the monitoring wells will be screened to within 5 feet above the top of Hawthorn clay formation. The screen depths for Zone C monitoring wells will be placed approximately within the 30- to 40-foot depth range. Actual screen depths will be modified slightly based on site lithology at the well installation location, and the presence of contamination.

Extraction Wells

Drilling and installation of the extraction wells will be performed to the same requirements as the injection wells, with the following exceptions:

Extraction wells will be constructed of 4 inch diameter flush-threaded Schedule 40 PVC with a 10-foot long PVC Johnson wire-wrapped screen. Drilling methods will allow for installation of the well with a minimum annular sand pack thickness of 2 inches on all sides of the well screen (minimum 8.5-inch diameter boring).

Extraction wells will be completed with the same type flush steel water valve covers used for injection wells, except that the diameter will be 12 inches, a standard threaded cap will be provided, and no Camlock fitting will be used.

The extraction wells will be installed at the following depths and screen intervals:

One well within Zone B to a depth of to 25 feet with a screened interval between 15 and 25 feet bls, and one extraction well within Zone C with a screened interval between approximately 30 and 40 feet bls.

The Subcontractor will furnish all casing, fittings, caps, and plugs. Casing that fails, collapses, or separates during construction will be removed from the hole and repaired or replaced at Subcontractor's sole expense.

Filter Pack

The criteria cited by F.G. Driscoll in "*Groundwater and Wells*"(1986) (relevant excerpt from this book included in Appendix I) suggest selecting filter material that is 3 to 5 times the D50 of the native formation materials, or 3 to 6 times the D30. The terms "D50" and "D30" refer to the average diameter in millimeters of the formation sand grains where 50 percent of the material is coarser and 50 percent is finer (D50), or where 30 percent is coarser and 70 percent is finer (D30) based on sieve test results. An additional criterion is that the screen slot size chosen must be capable of retaining 90 percent or more of the sand filter pack material used.

Using the Driscoll criteria and the finest grain size results for the native formation sands, grain size curve matching indicates that either a 30/45 mesh sand or a 20/30 mesh sand is suitable for filter pack material at SA-17, as shown in the comparison chart included in Appendix I.

The filter pack sand to be used for SA-17 wells will be equivalent to that sold by Standard Sand and Silica in nearby Lake Wales, FL. The 20/30 mesh filter sand specifications on their website include grain size data (included in Appendix I). The 0.020-inch screen slot size chosen retains greater than 90 percent of the proposed 20/30 mesh filter pack material, and therefore meets the well design criteria.

The filter pack will be tagged continuously during this process to ensure proper placement. A tag line of appropriate length, adequately weighted, and clearly numbered in feet will be used to determine the fill level and will be supplied by the Subcontractor. Care must be taken to avoid overfilling the annulus with filter pack material. Should over filling occur, the Subcontractor must remove the filter pack to the desired depth or remove the entire casing and screen, as determined by the oversight geologist. Should the entire casing and screen be removed, the Subcontractor will re-drill the hole and reinstall the casing the screen at his own expense.

During drilling of unconsolidated materials or clays which will not stay open without the hollow stem augers in place, the filter pack will be placed after the well casing is set to the correct depth and as the augers are being withdrawn. Augers will be pulled in 2 to 3-foot intervals during this process. Care must be exercised while placing the filter pack through the hollow stem augers to prevent bridging of the sand between the well casing and inside the auger. If the borehole will stay open without the augers in place, then the well can be installed after augers have been removed. The well will then be surged and additional sand will be placed if required. Frequent measurements will be made with a weighted tape, provided by the Subcontractor, to check the elevation of the filter pack and confirm that bridging has not occurred.

Wellhead Completion

Following filter pack tagging, a minimum 2-foot bentonite seal will be placed above the sand pack. Cement grout will be placed from the bentonite to the ground surface. The grout seal will be Portland cement conforming to the American Society for Testing and Materials (ASTM) C 150, Type II, with no more than 4 percent bentonite. The grout will be mixed in the following proportions: 94 lbs. of Type II Portland cement, up to 4 pounds of 100 percent sodium bentonite, and up to 8 gallons of potable water.

Each well will be secured with a locking, watertight cap within an 8-inch diameter steel manhole. The manhole will be set within a 24-inch square concrete apron finished slightly above grade. The riser pipe will be terminated with a 2-inch standard Camlock fitting and cap. The Camlock fitting will be attached to the well riser via a threaded collar so that it may be removed if necessary.

Borehole Abandoning

In the event that a borehole has to be abandoned, Subcontractor will completely fill the borehole from bottom to ground surface using neat cement grout in a manner approved by Engineer.

Well Development

Each installed well will be developed in accordance with all applicable State of Florida and local regulations. The subcontractor will containerize, characterize, and transport and dispose of all generated development water.

No detergents, soaps, acids, bleaches, or additives will be used during well development. Well development will be initiated no sooner than 24 hours following well installation.

Development will continue until water representative of the aquifer is produced from the well and until pH, conductivity, and temperature measurements have stabilized, and a representative flow rate for the well is determined by pumping. The Site Supervisor will supply the meters and will be the sole judge as to when development is complete and may, therefore, increase the total development time. Water from development will be contained and disposed in accordance with waste management procedures described in this Statement of Work.

In an effort to ensure that the performance of the groundwater extraction wells is adequate for the EOS® recirculation effort, the deep extraction well will be installed first, and a continuous lithologic log will be recovered to select the screened interval. After installation, the well will be developed by pumping and surging to dislodge and remove fine-grained aquifer material.

During the development process, an informal step drawdown test will be performed to evaluate the yield of the well. The pumping rate will be varied and the drawdown of the water level in the well will be checked at the various rates to determine the average rate the well can be pumped without creating unacceptable drawdown. The intermediate extraction well will be tested during development in a similar fashion.

Decontamination

Decontamination of the drill rig, augers, pipes, bits, tools, and all downhole equipment will consist of high pressure, low volume steam-cleaning at the temporary drilling equipment decontamination pad. A high-pressure, low volume steam cleaning device will be provided by the subcontractor. The subcontractor will also provide all detergents, solvents, buckets and brushes necessary for decontamination of sampling equipment and for the mobile drilling equipment decontamination pad. Water from a potable source and a power source will be provided by the subcontractor. All tools and drilling equipment to be placed in the drill hole and the rear of the drill rig will be steam-cleaned before drilling begins, between each boring, and after work is completed.

Management of IDW resulting from well installation and sampling activities, will be performed in accordance with Section 5.0, Waste Management Plan included in this Work Plan.

4.6 Mobilization of EOS® Delivery and Recirculation System

The EOS® recirculation process will be regulated using a process trailer as indicated earlier. The process trailer, associated tools and equipment, and Solutions personnel who will install the piping, fittings and other appurtenances associated with the recirculation effort will mobilize to the site from Solutions' offices in Raleigh, NC.

The process trailer will be staged at an appropriate distance near TTZ-1 as shown in the site layout on Figure 4-1.

4.7 Installation of Temporary Aboveground Piping and Appurtenances

The recirculation process involves conveying diluted EOS® to the injection wells from the dosimeter, and conveying groundwater from the extraction well to the groundwater holding tank. Based on the PID shown in Figure 3-2, the liquids will be conveyed using 2-inch PVC piping. Secondary containment will be provided using secondary piping, high density polyethylene (HDPE) liners and berms placed under pipe connections to prevent spills and leaks from discharging into the ground. Alternately, flexible HDPE piping or secondary PVC piping to encase delivery piping will be used to minimize the number of connections and eliminate the possibility of leaks.

4.8 Electrical Power and Telephone Connections

Electrical power will be provided by a generator to be procured by Solutions. No permanent telephone connections are available currently at the SA 17 site. Due to the relatively short duration of the field effort, all communication will be conducted using field cell phones that are equipped to contact local emergency authorities.

Telephone service will be provided to the treatment building, and the JV-II will coordinate with Bell South for the service.

4.9 Recirculation System Startup, Testing and Optimization

Prior to injection of the diluted EOS® and extraction of groundwater, all equipment will be tested using clean water from the fire hydrant to ensure that there are no leaks in the fittings. Any leaks noticed will be repaired prior to startup of the recirculation process.

All instrumentation including in-line filters, dosimeter, pressure and flow controls and injectate amendment units (sodium bromide tracer addition unit and pH amendment unit) will be checked to make sure they are functioning properly and providing the readings within the operational range of the recirculation process.

4.10 Full-scale Operation of EOS® Recirculation System

After initial startup and testing is done on the process trailer and associated equipment, full-scale operation of the EOS® recirculation system will be performed as described below.

Step 1: Establishment of Cone of Depression and Hydraulic Gradient Reversal

The primary step in the full-scale recirculation process will be to conduct extraction of groundwater from the central extraction wells. Prior to beginning EOS® injections, a cone of water table surface depression must be created around the extraction wells to ensure that local hydraulic gradients are reversed and capture of the EOS® solution within the treatment zone will occur. The extraction wells will be started and adjusted to the design flow rate of 3 gpm in the Zone B extraction well and 6 gpm in the Zone C extraction well, and the recovered water generated will be collected in the onsite storage tank. The holding tank will be of sufficient capacity (up to 21,000 gallons) to provide reserve capacity while the injection and extraction flow rates are being balanced. The durations of the initial pumping from the extraction wells will be determined in the field based on observations of drawdown, storage tank capacity, sustenance of the design extraction flow rate of 9 gpm that is currently assumed.

Step 2: Dilution of EOS® Concentrate, Amendment of Injectate, and Injection of Injectate

The next step in the recirculation process is to dilute the EOS® with the recovered groundwater to the initial dosage concentration of a 10 percent solution (1 part EOS® to 9 parts water) using the Dosatron dosimeter.

The total quantity of EOS® calculated by Solutions is 18 drums (approximately 9,900 gallons). At a 10 percent solution, this will result in a total of approximately 1,000 gallons of injectate.

Amendment units (sodium bromide tracer unit and sodium bicarbonate pH-buffering unit) will be adjusted to provide the required dosage. The dosages will be pre-determined by the Solutions field technician operating the equipment. A quantity of 250 pounds of sodium bicarbonate has been estimated by Solutions and this quantity will be distributed over the duration of the EOS® injection. The sodium bromide tracer will be introduced at an average concentration between 500 to 1,000 mg/L, as instructed by Solutions.

The amended EOS® injectate will be introduced into the injection wells. The injectate will be introduced at a low flow rate of 0.5 to 1.0 gpm per well, in order to prevent excessive groundwater mounding within the source area. To achieve an equilibrium between the injection and extraction flow rates, final injection and extraction flow rates will be adjusted based on the findings of the aquifer pump test, and field measurements of water levels in the wells within the treatment zone.

Water levels will be frequently measured in the extraction wells so that water level drawdown can be tracked. Based on these measurements, the pump flow rate will be adjusted to maintain the maximum stable drawdown without exposing the pump intake or screen.

Water levels in the new interior (sentry) monitor wells and the new injection wells will also be measured during pumping least once per hour for up to 8 hours, until consistent drawdown levels are observed in these wells.

Step 4: Verification of EOS® Propagation and Breakthrough

The first indication of EOS® migration from the injection wells toward the extraction well will be in the intermediate sentry wells 17-MW-57B and 17-MW-57C (shown on Figure 3-1). Groundwater samples collected periodically from these wells will be checked for the presence of sodium bromide tracer previously added to the injectate. Once the tracer has been detected in the groundwater sample, a field test kit will be used to measure TOC concentrations and compared to the baseline TOC concentrations in the well in order to verify the presence of EOS® in the sentry wells. Additionally, EOS® is expected to have a milky appearance and a visual check will also be made for milkiness. Based on an evaluation of the travel time of the EOS® solution from the injection well to the first pair of sentry wells, similar verification will be conducted in the second pair of sentry wells (17-MW-56B and 17-MW-56C) and finally in the extraction wells 17-EW-01 and 17-EW-02.

If travel times to the first sentry wells indicate that the propagation of EOS® is proceeding significantly slower than expected (approximately 10 days from injection wells to extraction wells), the EOS® solution will be diluted further. Figure 4-6 shows a decision logic diagram to assist in the procedure to continue recirculation based on verification of EOS® propagation through the treatment area.

Recirculation of extracted groundwater will continue until breakthrough as described above has occurred as confirmed by the presence of EOS® in the extraction wells. This breakthrough is the performance goal for the recirculation effort and will represent successful completion of the field implementation of the RA.

The frequency of inspections for EOS® breakthrough will be based on the actual pumping rates attained, but will be performed at a minimum of 3 times per day; once in the morning, once at mid-day, and once at the end of the shift.

Step 5: Purging of Storage Tank and Recirculation Equipment and Piping

Extraction well pumping will continue for at least 4 hours after EOS® breakthrough to maintain optimal gradients for EOS® distribution. After all 18 drums of EOS® have been introduced and breakthrough has occurred, the remaining water in the frac tank will be re-injected into the injection wells at the established flow rates.

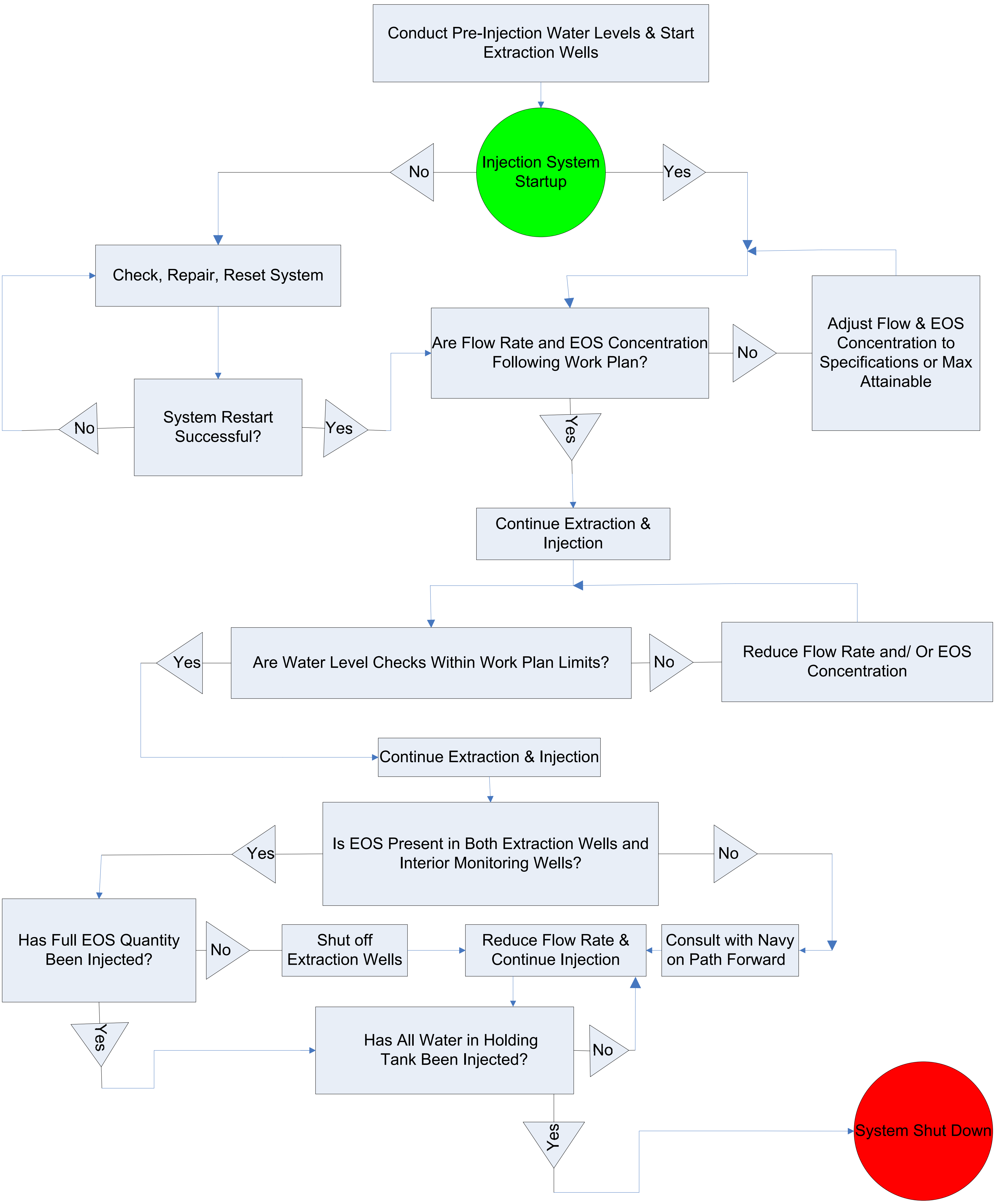


FIGURE 4-6
Decision Logic Diagram for EOS Recirculation
Study Area 17, NTC Orlando

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After the recirculation activities are completed, all piping, equipment and the storage tanks will be flushed clean with the water supply from the fire hydrant and the rinsate will be injected into the injection wells. Any remaining decontamination water will be contained in drums for offsite disposal.

4.11 Site Restoration and Demobilization

Erosion controls such as hay bales and silt fences will be removed after the process trailer and associated piping have been removed from the site. The process trailer will be inspected prior to being driven on public roads to ensure safe transportation offsite.

4.12 Decontamination

All JV-II and subcontractor personnel will be responsible for properly decontaminating their personnel and equipment prior to exiting the Exclusion Zone, without exception. Furthermore, the well-drilling rig will be decontaminated between each well installation. Any cross-contamination of Navy property or public thoroughfare will be restored. All debris/rinsate generated by the treatment activities will be properly containerized, removed from the site, and properly and legally disposed of in accordance with Section 5.0, Waste Management Plan. Decontamination of personnel and PPE will be performed in accordance with the Health and Safety Plan and applicable provisions of 29 Code of Federal Regulations (CFR) 1910.120. All waste PPE will be disposed of with the waste stream associated with its usage.

4.13 Offsite Disposal of Wastes

All waste generated at SA 17 will require characterization sampling/analysis, profiling, transportation, and disposal. Disposal/recycling facility information will be provided in accordance with Section 4.0, Sampling and Analysis Plan, and Section 5.0, Waste Management Plan.

The typically required disposal characterization analyses include:

- For Soil: Toxicity Characteristic Leaching Procedure (TCLP) volatiles by U.S. USEPA Method 1311/8260B, TCLP semi-volatiles by USEPA Method 1311/8270C, TCLP pesticides/herbicides by USEPA Method 1311/8081A/8151A, TRPH by Florida Petroleum Residual Organic (FL-PRO) Method, polychlorinated biphenyls (PCBs) by USEPA Method 8082, TCLP metals by USEPA Method 1311/6010B/7470A and reactivity, corrosivity, and ignitability by USEPA Method 7.3.3/1010/1030.

- For Water (i.e., decontamination water, excavation contact water, etc.): Target Compound List (TCL) volatiles by USEPA Method 8260B, TCL semi-volatiles by USEPA Method 8270C, TCL pesticides/herbicides by USEPA Method 8081A/8151A, TRPH by FL-PRO Method, PCBs by USEPA Method 8082, TAL metals by USEPA Method 6010A/7471, and reactivity, corrosivity, and ignitability by EPD Method.

In addition, JV-II will perform any other analyses required by the disposal/recycling facilities. The number of waste characterization samples required will be in accordance with the disposal/recycling facilities' requirements. Once analytical results are received, waste approval packages will be provided. The packages will include:

- Waste profile forms naming the U.S. Navy as the generator of the waste
- Analytical summary table(s) applicable to the waste
- Letter of approval from the proposed waste disposal facility to accept the waste
- Pre-printed manifests naming the U.S. Navy as the generator of the waste
- Waste description and shipping labels
- State and USEPA Land Disposal Restriction (LDR) forms (for hazardous wastes)
- Volatile Organic Compounds (VOCs) <500 ppm forms (when applicable)

Once the waste profile and manifests have been signed and upon receipt of waste stream approval from the disposal facility, all the waste material will be loaded and transported to an FDEP-permitted disposal facility in good standing with federal, state and local regulatory agencies. Certificates of destruction/disposal/recycling/treatment will be obtained. All waste that leaves the site will be tracked using the Transportation & Disposal (T&D) Log.

4.14 Project Submittals

The Site Manager will be responsible for preparing a field activity summary for the site describing the work performed and quantities of contaminated materials removed at the site. All project deliverables and reporting requirements are outlined in the Submittal Register of Appendix B. The following sections describe some of the major submittal documents.

4.14.1 As-built Construction Drawings

At the completion of the RA implementation, the locations of the injection wells, extraction wells and newly-installed monitoring wells will be surveyed by a surveyor registered in the State of Florida and entered into the EGIS for SA 17.

Digital photographs will be captured at all stages of the field work as part of this RA and submitted as part of the Living CD requirements of this contract.

4.14.2 Quarterly Performance Monitoring Reports

Quarterly performance monitoring reports detailing the operational parameters observed and analytical results of routine sampling will be submitted to the OPT. These reports will summarize the findings of treatment progress based on analytical results and discuss trends in MNA parameters and contaminant concentration. Recommendations if any, for future monitoring will also be discussed in these reports.

4.14.3 Annual Performance Monitoring Completion Report

A completion report will be provided upon completion of the first (base) year of performance monitoring. This report will include:

- Introduction
- Summary of Remedial Action

- Final Health and Safety Report
- Summary of Record Documents
- Field Changes and Contract Modifications
- Final Documents
- Complete Set of all Field Test and Laboratory Analytical Results
- Complete Set of all Data Validation Results
- Documentation of Offsite Transportation and Treatment of Materials, QC Summary Report
- Site Photographs, if any

The report will also include an evaluation of the system, including quantities of EOS® solution injected, groundwater treated, total mass of contaminants removed, problems encountered, and solutions implemented.

4.15 Project Schedule

The major project activities and estimated durations for each are outlined below.

• Pre-construction Meeting/Submittal Preparation/Reviews	45 days
• Abandoning of ISCO Injection Wells	2 days
• Mobilization	2 days
• Installation and Development of Injection, Extraction and Monitoring Wells	10 days
• Baseline Sampling of Monitoring Wells	5 days
• Start-up and testing of EOS® Injection and Recirculation System	1 days
• Full-Scale Implementation of EOS® Injection and Recirculation	20 days
• Demobilize	2 days
• Performance Monitoring	1 year

4.16 Communications Plan

Table 4-1 is a communication matrix with the lines of communications for the Navy and JV-II. Table 4-2 provides a project personnel directory.

TABLE 4-1
Communications Matrix

Agviq/CH2M HILL JV- II Position	Navy Direct Report
Executive Sponsor – Ray Tyler	Rick Davis, Contracting Officer (CO)
Program Manager – Craig Miller	Dorothy Okamoto, COTR
Deputy Program Manager – Scott Smith	Dorothy Okamoto, COTR
TO Project Manager – Sam Naik	Barbara Nwokike, RPM Paul Cotter, ROICC

TABLE 4-2
Project Personnel Directory

Contact	Company and Address
Craig Miller, Program Manager Scott Smith, Asst. Program Manager Sam Naik, Project Manager Joe Giandonato, Contracts Administration Manager Richard Rathnow, Health and Safety Manager Eric Burrell, QA/QC Manager	Agviq-CH2M HILL JV-II, C/o CH2M Hill Constructors, Inc. 115 Perimeter Center Place, N.E. Suite 700 Atlanta, GA 30346-1278 (770) 604-9182
Lemarle McKee, Contracting Officer (Lemarle.Mckee@navy.mil) (407)-380-4976	Southern Division Naval Facilities Engineering Command ROICC Mayport P.O. Box 280073 Mayport, FL 32228-0073
Dorothy Okamoto, COTR (843) 820-5940	Southern Division Naval Facilities Engineering Command P.O. Box 190010 North Charleston, SC 29419-9010
Barbara Nwokike, RPM (Barbara.Nwokike@navy.mil) (843) 820-5566	As above
Paul Cotter, ROICC (paul.cotter@navy.mil) (904) 270-6317 ext 110	Southern Division Naval Facilities Engineering Command NAVFAC EFA Southeast P.O. Box 280073 Building 1966 Mayport, FL 32228-0073

4.17 Traffic Control Plan

Traffic control at the site will be the responsibility of the JV-II Site Superintendent. The JV-II will minimize disturbance to facility operations during project activities. The JV-II will consult with on-site Navy personnel to evaluate site access, placement of equipment, and traffic flow to minimize the impact of this work to the NTC Orlando operations, and review all Navy regulations and standard operating procedures (SOPs) regarding vehicle movement and control inside NTC Orlando.

5.0 Sampling and Analysis Plan

The SAP provided in this Work Plan outlines the required sampling activities associated with the remedial activities at SA 17. This SAP outlines the required analyses for groundwater monitoring for treatment evaluation and MNA sampling in the vicinity of TTZ-1. Sampling under the scope of work includes baseline sampling conducted prior to EOS® recirculation within TTZ-1 to establish baseline conditions, and quarterly post-injection monitoring.

5.1 Baseline Groundwater Characterization Sampling

To assess the nature and extent of the dissolved CVOC plume and current geochemical conditions in the vicinity of TTZ-1, the following existing groundwater monitoring wells have been selected to establish a monitoring network for performance assessment of the EOS® treatment. The following monitoring wells proposed to be newly installed are indicated as such:

- EOS-17-53-CMT (multi-port well with 2 screens each in Zones B and C)
- EOS-17-54B
- EOS-17-54C
- EOS-17-55B
- EOS-17-55C
- EOS-17-56B
- EOS-17-56C
- EOS-17-57B
- EOS-17-57C
- EOS-17-58B
- EOS-17-58C

Table 5-1 lists the parameters, methods of analysis, holding times and container requirements for these samples. Table 5-2 shows a detailed sampling matrix to indicate which wells will be sampled during baseline and each quarter of the performance monitoring period.

Table 5-1
Sampling and Analysis Summary Table
CTO 06, Former Naval Training Center (NTC), Orlando,Florida

Sample Task	Sample Point	Matrix	Sampling Frequency	Approx Sample No	Sampling Method (Note 1)	Sampling Equipment (Note 1)	TAT (Note 2)	Data Package Reqmnt	Required Analysis	Analytical Method	Holding Time	Sample Preservation	Containers
Groundwater Characterization Sampling													
Groundwater Treatment Performance and Natural Attenuation Parameters Sampling	Monitoring wells EOS-17-53B1 EOS-17-53B2 EOS-17-53C1 EOS-17-53C2 EOS-17-54B EOS-17-54C EOS-17-55B EOS-17-55C EOS-17-56B EOS-17-56C EOS-17-57B EOS-17-57C EOS-17-58B EOS-17-58C	Water	Baseline then Quarterly for the first year	14 + 2 Dup + 1MS/MSD = 17	Grab	Peristaltic Pump; Teflon Tubing	14 days	CCI Level C	Volatiles	8260B	14 days	HCL pH <2; Cool to 4°C	(2) 40 mL vial
	Same as above	Water	Baseline then Quarterly for the first year	1 per well per event	Grab	Peristaltic Pump; Teflon Tubing; Horiba U-10 Water Quality Checker; ORP meter (if not included on Horiba)	ASAP	Screening	DO, Temperature, pH, Specific Conductance, Turbidity, ORP	Field Direct Read Meter	N/A	N/A	N/A
	Same as above	Water	Baseline then Quarterly for the first year	1 per well per event	Grab after flow-through cells show stable conditions	Hach or CHEMet field kit	ASAP	Screening	DO	Chemetrics Field Kit K7501	N/A	N/A	N/A
									Carbon Dioxide	Chemetrics Field Kit K1920	N/A	N/A	N/A
									Sulfide	Chemetrics Field Kit K9510	N/A	N/A	N/A
									TOC	Hach Field Kit 2760445	N/A	N/A	N/A
									Manganese	Chemetrics Field Kit K6502D	N/A	N/A	N/A
									Iron II (Ferrous)	Chemetrics Field Kit K26210	N/A	N/A	N/A
									Alkalinity	Hach Field Kit 24443-01	N/A	N/A	N/A
Groundwater Treatment Performance and Natural Attenuation Parameters Sampling	Same as above	Water	Baseline then Quarterly for the first year	14 + 2 Dup + 1MS/MSD = 17	Grab	Peristaltic Pump; Teflon Tubing	14 days	CCI Level C	Dissolved Hydrogen	Microseeps			
									Dissolved Methane/Ethane/Ethene	RSK 175	14 days	HCL pH <2; Cool to 4°C	(2) 40 mL vial
									Sulfate	300.0/375	28 days	Cool to 4°C	(1) 250 mL HDPE
									Chloride	SW9056			
									Iron	SW-6010B	6 months	HNO_3 pH< 2; Cool to 4°C	(1) 500mL HDPE

Notes:
1) In accordance with FDEP SOPs
2) TAT is in calendar days

ATL\WP\NAVY JV\TO 1\SA17 Final RAWP Table 5-1- ver 2.xls

Table 5-1
Sampling and Analysis Summary Table
CTO 06, Former Naval Training Center (NTC), Orlando,Florida

Sample Task	Sample Point	Matrix	Sampling Frequency	Approx Sample No	Sampling Method (Note 1)	Sampling Equipment (Note 1)	TAT (Note 2)	Data Package Reqmnt	Required Analysis	Analytical Method	Holding Time	Sample Preservation	Containers
Groundwater Treatment Performance and Natural Attenuation Parameters Sampling	Same as above	Water	Baseline then Quarterly for the first year	14 + 2 Dup + 1MS/MSD = 17	Grab	Peristaltic Pump; Teflon Tubing	14 days	CCI Level C	Iron III	Calculated	6 months	HNO_3 pH< 2; Cool to 4^{o}C	(1) 500mL HDPE
	Monitoring wells EOS-17-54B EOS-17-54C EOS-17-56B EOS-17-56C EOS-17-57B EOS-17-57C EOS-17-58B EOS-17-58C	Water	Baseline before injection and first two quarters following injection	1 per well per event	Grab	Peristaltic Pump; Teflon Tubing; Horiba U-10 Water Quality Checker; ORP meter (if not included on Horiba)	14 days	CCI Level C	Sodium	200.7	28 days		
									Total Dissolved Solids	E160.1	7 days	Cool to 4^o C	(1) 500mL HDPE
									Total Suspended Solids	E160.2	7 days	Cool to 4^o C	(1) 500mL HDPE
									TRPH	FL-PRO	7 days ext; 40 days analysis	Cool to 4^o C	(1) 4 oz. Amber glass
									Polysorbate 80	SM 5540D	48 hours	Cool to 4^{o}C	(4) 500 mL glass
							ASAP	Screening	DO, Temperature, pH, Specific Conductance, Turbidity, ORP, TOC, NaBr tracer	Field Direct Read Meter; Hach Field test kit #: 2815945 for TOC; Hach Ion Selective Electrode-Bromide Product # E41M001 for NaBr			
			Baseline before injection, 3rd and 4th quarter following injection	1 per well per event	Grab	Peristaltic Pump; Teflon Tubing; Horiba U-10 Water Quality Checker; ORP meter (if not included on Horiba)	14 days	CCI Level C	q-DNA	qPCR (Microbial Insights Lab			
									Volatile Fatty Acids	VFA(Microbial Insights Lab			
									Phospholipid Fatty Acids	PLFA(Microbial Insights Lab Method)	N/A	N/A	N/A
Aqueous Waste Characterization													
Disposal of Aqueous Waste	Portable Tank or Drums	Water	Once per container or per 10 drums	As necessary	Grab	Drum thief or dip jar	7 days	CCI Level A	TCL Volatiles	8260B	14 days	HCl pH< 2; Cool to 4^{o}C	(2) 40 ml vial
									TCL Semi-volatiles	8270C	7 days ext; 40 days analysis	Cool to 4^{o}C	(4) 1L amber glass
									TCL Pesticides	8081A	7 days ext; 40 days analysis	Cool to 4^{o}C	
									Herbicides	8151A	7 days ext; 40 days analysis	Cool to 4^{o}C	
									TAL Metals	6010B/7470A	6 months	HNO_3 pH< 2; Cool to 4^{o}C	(1) 500mL HDPE
									Corrosivity	9040C	ASAP	Cool to 4^{o}C	(1) 1L amber glass
									Ignitability	1010	ASAP	Cool to 4^{o}C	(1) 1L amber glass

Notes:
1) In accordance with FDEP SOPs
2) TAT is in calendar days

ATL\WP\NAVY JV\TO 1\SA17 Final RAWP Table 5-1- ver 2.xls

Table 5-1
Sampling and Analysis Summary Table
CTO 06, Former Naval Training Center (NTC), Orlando,Florida

Sample Task	Sample Point	Matrix	Sampling Frequency	Approx Sample No	Sampling Method (Note 1)	Sampling Equipment (Note 1)	TAT (Note 2)	Data Package Reqmnt	Required Analysis	Analytical Method	Holding Time	Sample Preservation	Containers
Soil Waste Characterization													
Soil Characterization Sampling	Drums	Soil	Once	2	Composite grabs from 6 points into 1 sample (VOCs collected from a single grab)	Hand Auger, SS spoon, SS bowl	14 day	CCI Level A	TCLP Volatiles	1311/8260B	14 day TCLP extr; 14 day analysis	Cool to $4^{o}C$	(1) 4 oz glass
									TCLP Semi-Volatiles	1311/8270C	14 day TCLP extr; 7 day extr; 40 day analysis	Cool to $4^{o}C$	(5) 8 oz glass
									TCLP Metals	1311/6010B/7470A	6 month TCLP extr; 6 month analysis Hg: 28 day TCLP extr; 28 day analysis		
									TCLP Pesticides	1311/8081A	14 day TCLP extr; 7 day extr; 40 day analysis		
									TCLP Herbicides	1311/8151A	14 day TCLP extr; 7 day extr; 40 day analysis		
									Corrosivity	9045C	ASAP		
									Ignitability	1010/1030	ASAP		

Notes:
1) In accordance with FDEP SOPs
2) TAT is in calendar days

ATL\WP\NAVY JV\TO 1\SA17 Final RAWP Table 5-1- ver 2.xls

Table 5-2
Groundwater Monitoring Well Sampling Event Matrix
Bioremediation using EOS, Study Area 17, NTC Orlando, FL

	Analysis	Field Parameters (DO/Temp/pH/Specific Conductance, Turbidity, ORP)	Diss.Oxygen, Carbon Dioxide, Sulfide, TOC, Manganese, Ferrous Iron, Alkalinity	Dissolved Hydrogen	Volatiles	Dissolved Methane/ Ethane/ Ethene	Sulfate	Chloride	Total Iron	Bromide	TOC	Sodium	Total Diss. Solids	Total Suspended Solids	TRPH	Polysorbate 80	Microbial Analyses-qDNA, VFA, PLFA
	Method	Direct-Reading Instr.	Chemetrics or Hach Field Kits - see Table 5.1 for field kit model nos.	Microseeps	8260B	RSK 175	300.0/375	SW9056	SW-6010B	Hach Ion Selective Electrode-Bromide Product # E41M001	Hach Field Kit 2760445	200.7	E160.1	E160.2	FL-PRO	SM5540D	Microbial Insights Method
Sampling Location	**Sampling Event**																
EOS Diluted Injectate	Before Injection									x	x	x	x	x	x	x	
EOS-17-53B1	Baseline	x	x	x	x	x	x	x	x								
EOS-17-53B2	Qtr 1	x	x	x	x	x	x	x	x								
EOS-17-53C1	Qtr 2	x	x	x	x	x	x	x	x								
EOS-17-53C2	Qtr 3	x	x	x	x	x	x	x	x								
	Qtr 4	x	x	x	x	x	x	x	x								
EOS-17-54B	Baseline	x	x	x	x	x	x	x	x			x	x	x	x	x	x
EOS-17-54C	Qtr 1	x	x	x	x	x	x	x	x	Sample during Injection	Sample during Injection	x	x	x	x	x	
	Qtr 2	x	x	x	x	x	x	x	x	to verify EOS	to verify EOS	x	x	x	x	x	
	Qtr 3	x	x	x	x	x	x	x	x	Propagation through	Propagation through						x
	Qtr 4	x	x	x	x	x	x	x	x	aquifer	aquifer						x
EOS-17-55B	Baseline	x	x	x	x	x	x	x	x	Sample during Injection	Sample during Injection						
EOS-17-55C	Qtr 1	x	x	x	x	x	x	x	x	to verify EOS	to verify EOS						
	Qtr 2	x	x	x	x	x	x	x	x	Propagation through	Propagation through						
	Qtr 3	x	x	x	x	x	x	x	x	aquifer	aquifer						
	Qtr 4	x	x	x	x	x	x	x	x								
EOS-17-56B	Baseline	x	x	x	x	x	x	x	x			x	x	x	x	x	x
EOS-17-56C	Qtr 1	x	x	x	x	x	x	x	x	Sample during Injection	Sample during Injection	x	x	x	x	x	
	Qtr 2	x	x	x	x	x	x	x	x	to verify EOS	to verify EOS	x	x	x	x	x	
	Qtr 3	x	x	x	x	x	x	x	x	Propagation through	Propagation through						x
	Qtr 4	x	x	x	x	x	x	x	x	aquifer	aquifer						x
EOS-17-57B	Baseline	x	x	x	x	x	x	x	x			x	x	x	x	x	x
EOS-17-57C	Qtr 1	x	x	x	x	x	x	x	x	Sample during Injection	Sample during Injection	x	x	x	x	x	
	Qtr 2	x	x	x	x	x	x	x	x	to verify EOS	to verify EOS	x	x	x	x	x	
	Qtr 3	x	x	x	x	x	x	x	x	Propagation through	Propagation through						x
	Qtr 4	x	x	x	x	x	x	x	x	aquifer	aquifer						x
EOS-17-58B	Baseline	x	x	x	x	x	x	x	x			x	x	x	x	x	x
EOS-17-58C	Qtr 1	x	x	x	x	x	x	x	x	Sample during Injection	Sample during Injection	x	x	x	x	x	
	Qtr 2	x	x	x	x	x	x	x	x	to verify EOS	to verify EOS	x	x	x	x	x	
	Qtr 3	x	x	x	x	x	x	x	x	Propagation through	Propagation through						x
	Qtr 4	x	x	x	x	x	x	x	x	aquifer	aquifer						x

NOTES: Please refer to Table 5.1 for sampling frequency and parameters for remediation waste derived from baseline and quarterly well purging events.

5.2 Performance Monitoring Sampling

The groundwater monitoring wells listed above for the baseline characterization sampling will be sampled on a quarterly basis during the first year following the EOS® recirculation effort. These groundwater samples will be analyzed for CVOCs, MNA and biological parameters as listed in Table 5-1. Based on the initial rounds of sampling, some of these parameters may be discontinued after consultation with the OPT.

5.3 Waste Characterization Sampling and Analyses

5.3.1 Soil Characterization

Waste characterization samples will be collected to evaluate the handling, transportation, and disposal requirements of any contaminated soil accumulated during construction activities. Samples will be collected as described below, delivered to a Navy, U.S. Army Corps of Engineers (USACE), or Air Force Center for Environmental Excellence (AFCEE)-approved and Florida-certified laboratory, and analyzed for the parameters listed in Table 4-2. Drill cuttings will be generated from the various injection and extraction well borings performed at SA 17. These cuttings will be placed into roll-offs or drums. One sample per 10 drums will be collected. The volatile sample will be collected as a single grab from the drum suspected to be the most contaminated. The samples will be collected for disposal characterization as follows:

1. Bore down into drum approximately 6 to 12 inches and fill volatile sample container. Container must be packed and have no headspace.
2. Continue to collect several spoonfuls of the soil into a stainless steel bowl.
3. Homogenize the sample with the stainless steel spoon using the quartering technique.
4. Fill the appropriate sample jars approximately three-fourths full with the homogenized sample.
5. Close the jars, label, and package the samples for shipment to the laboratory.

A CH2M HILL Level B package will be required along with appropriate Quality Control samples for the required waste characterization and incidental waste stream samples. All analytical data will be submitted in both hard copy and electronic file format.

5.3.2 Liquid Waste Characterization

Waste characterization samples will be collected to evaluate the handling, transportation, and disposal requirements of generated decontamination water, well development water and any residual water extracted but not re-injected in the course of performing the EOS® injections. It is anticipated that any aqueous waste generated will be containerized in drums or portable tanks. Liquid samples will be collected as follows and delivered to a Navy -approved and Florida certified laboratory, and analyzed for the parameters listed on Table 5-2.

One composite sample will be collected per drum for a maximum of six drums or one per tank using either a dip jar or bailer. The sample containers for volatiles analyses will be filled first. The 40-milliliter (ml) vials will be filled so that there is no headspace in each vial. The sample containers for the remaining analyses will then be filled.

A CCI Level B package will be required along with appropriate QC samples for the required waste characterization and incidental waste stream samples. All analytical data will be submitted in both hard copy and electronic file format.

5.4 Data Quality Levels for Measurement Data

The data quality levels (DQLs) for each sampling task described above are listed in Table 4-1. The sampling and analytical requirements, along with the required level of quality and data packages are listed in Table 5-3.

Laboratories performing the analyses will meet the qualifications and certifications as per the Navy's *Installation Restoration Program Chemical Data Quality Manual (IR CDQM) FESC SP-2056-ENV, September 1999 (NFESC)*. Laboratories will have undergone the laboratory approval process as defined in the subject NFESC document for the scope of work performed under the Installation Restoration Program (IRP). The Navy-approved laboratory will also have certification from the State of Florida through the National Environmental Laboratory Accreditation Program (NELAP) will be used for all sample analyses.

TABLE 5-3
Data Quality Levels

Sampling Activity	Data Quality Level Category
Baseline and Performance Monitoring Groundwater Characterization Sampling	Definitive
MNA Groundwater Sampling	Definitive
Waste characterization of the contaminated soils/solids and aqueous waste (offsite laboratory analyses)	Definitive

5.5 Field Quality Control

One trip blank sample will be provided at a frequency of one per sample cooler containing volatile samples when collecting groundwater characterization samples. No field QC samples are required when collecting disposal samples.

5.6 Analytical Methods

Samples will be collected in accordance with the requirements for the analytical methods summarized in Table 5-1.

Preliminary results will be forwarded to Bethany Garvey, JV-II in accordance with Table 5-1. The final hard copy data and electronic file will be delivered to Bethany Garvey at the following address within 14 days of sample receipt.

Bethany Garvey
Agviq-CH2M HILL JV-II
c/o CH2M HILL Constructors, Inc.
115 Perimeter Center Place, N.E.
Suite 700
Atlanta, GA 30346
(770) 604-9182 x 263
(678) 604-9282 (fax)
Bethany.Garvey@ch2m.com

6.0 Waste Management Plan

The Waste Management Plan describes the waste management requirements and procedures for remediation activities at SA 17 located at NTC Orlando, Orlando, Florida.

Wastes generated during these activities will be managed in a manner consistent with the provisions of the appropriate State of Florida and federal regulations.

The waste streams associated with this scope of work may include:

- Aqueous waste (including development, purge, and decontamination water)
- Drill cuttings (soil) from the well installations
- Spent or contaminated sampling equipment
- PPE
- Uncontaminated general construction debris (such as caution tape, barricades, signs, packing materials, excess piping, plastic sheeting, etc.).

6.1 Waste Characterization

It is assumed that most of the wastes generated at SA 17 will be non-hazardous. However, some of the IDW, e.g., drill cuttings, could exhibit sufficiently high concentrations of CVOC compounds to qualify as characteristically hazardous wastes.

The Sampling and Analysis Plan provides detailed information on the waste sampling and analysis requirements. However, in some cases, offsite facilities may require additional analyses to evaluate the waste stream prior to acceptance. All wastes will be classified as required under the Resource Conservation and Recovery Act (RCRA). Uncontaminated wastes and debris, such as construction and demolition debris, will be characterized using process knowledge and generally will be classified as municipal solid waste.

Waste characterization information for wastes will be documented on a waste profile form provided by the offsite treatment or disposal facility as part of the waste acceptance process. An approved copy of the fully executed waste profile will be received prior to offsite transportation of the material. Navy personnel will provide generator certification and signatures on all characterization and disposal paperwork. Under no circumstances should JVII personnel sign waste profiles or manifests on behalf of the Navy.

The profile typically requires the following information:

- Generator (Navy) information including name, address, contact, and phone/fax number
- Site name including street/mailing address
- Activity generating waste (e.g., groundwater remediation)

- Source of contamination (e.g., SA 17)
- Historical use for area (former motor pool maintenance area/vehicle wash rack)
- Physical state of waste (e.g., solid, liquid, etc.)
- Applicable hazardous waste codes for contaminants exceeding the toxicity characteristic as in Table 6-1.

TABLE 6-1
Hazardous Waste Codes for COCs Exceeding the Toxicity Characteristic

Constituent of Concern (COC)	EPA HW No.	Regulatory Level (mg/L) (Toxicity Characteristic)
Trichloroethene (TCE)	D040	0.5
Dichloroethene (DCE)	NA	NA
cis-1,2-Dichloroethene (cis-1,2-DCE)	NA	NA
1,1-Dichloroethene (1,1-DCE)	D029	0.7
1,1-Dichloroethane (1,1-DCA)	NA	NA
Vinyl Chloride (VC)	D043	0.2

6.2 Waste Management

6.2.1 Waste Storage Time Limit

Hazardous waste must be removed offsite within 90 days from the date of generation; non-hazardous and other wastes will be removed from the site as soon as possible. The date of generation (accumulation start date) is the day that a waste is first placed in a container or tank.

6.2.2 Labels

All containers/drums, tanks and roll-off boxes will be labeled, and labels will be visible. Hazardous waste labels will be used where a site has been pre-characterized, and is known to be contaminated with listed or characteristically hazardous wastes.

Pre-printed "**Hazardous Waste**" labels will include the following information:

- Accumulation start date (date waste first placed in container)
- Generator Name: U.S. Navy Southern Division, NTC Orlando
- EPA ID number for site (FL5170024736)
- Waste codes (see Table 5-1 above)

For containers of less than 110 gallons, the manifest number must be on the label before transporting.

Containers, tanks, and roll-off boxes of known non-hazardous waste will have pre-printed "**Non-Hazardous Waste**" labels that include the following information:

- Accumulation start date
- Generator Name: U.S. Navy Southern Division, NTC Orlando
- Site EPA ID Number (FL5170024736)
- Waste-specific information (e.g., contaminated soil)

When waste characterization is unknown and analytical results are pending, the pre-printed "**Analysis Pending**" label will be used until analytical results are received and reviewed prior to final waste characterization. These wastes will be labeled with information equivalent to that provided on a Hazardous Waste label:

- Accumulation start date
- Generator Name: U.S. Navy Southern Division, NTC Orlando
- Site EPA ID Number (FL5170024736)
- Waste-specific information (e.g., contaminated purge water)

6.2.3 Waste Management Requirements

All wastes will be contained or otherwise managed to prevent the spread of contamination. Waste-specific requirements include the following:

- Aqueous wastes will be contained in drums and tanks.
- Contaminated soil (e.g., drill cuttings) will be placed in stockpiles or directly placed in drums or into lined roll-off boxes.
- Contaminated miscellaneous wastes such as sampling equipment and PPE will generally be contained in drums.
- Uncontaminated or decontaminated wastes, including construction debris, will be segregated and contained in drums, roll-off boxes, or may be placed neatly in storage piles, pending offsite T&D.

6.2.4 Waste Management Areas

6.2.4.1 Drums/Small Containers

- Drums and small containers of hazardous waste may be stored at the area of contamination (AOC), or will be transported to the temporary accumulation areas on wood pallets and secured together with non-metallic bonding.
- Drums will be inspected and inventoried upon arrival onsite for signs of contamination and/or deterioration.
- Adequate aisle space (e.g., 30 inches) will be provided for containers such as 55-gallon drums to allow the unobstructed movement of personnel and equipment. A row of drums should be no more than two drums wide.
- Each drum will be provided with its own label, as well as a unique identification number for tracking purposes. Labels and drum markings should be placed on drums such that they are easily visible for purposes of inspections, inventory, etc.

- Drums will remain covered except when removing or adding waste to the drum. Covers will be properly secured at the end of each workday.
- Drums will be disposed of with the contents. If the contents are removed from the drums for offsite transportation and treatment or disposal, the drums will be decontaminated prior to re-use or before leaving the site.
- **Secondary containment will be provided for drums of liquid waste.**

6.2.4.2 Portable Tanks

- Non-stationary tanks (such as steel cargo tanks or other wheeled tanks) will be used to accumulate hazardous aqueous waste.
- Tanks will be inspected upon arrival onsite for signs of deterioration and contamination. Any tank arriving onsite with contents will be rejected.
- Tanks will be provided with covers.
- Each tank will be labeled.
- Tanks will be provided with secondary containment.

6.2.4.3 Roll-off Boxes

- Roll-off boxes will be inspected upon arrival on-site. Any roll-off containers arriving with contents or obvious signs of contamination will be rejected.
- Roll-off boxes for contaminated soil will be provided with covers and disposable liners. Liners will be disposed of as contaminated debris.
- When not in use, securely fastened covers will be installed on all roll-off boxes.
- Old labels will be removed.
- Roll-off containers will be inspected by the transporter after removal of the liner and decontaminated in the event of evidence of liner failure.
- Covers and perimeter berms will be secured in-place when not in use and at the end of each workday, or as necessary to prevent wind dispersion or run-off from major precipitation events.
- Construction materials for the stockpiles that contact waste will be disposed of as contaminated debris.

Accumulation start dates will be recorded on a log or a sign located at the stockpile.

6.2.5 Security and Contingency Planning

Waste storage areas will contain emergency response equipment including fire extinguishers, decontamination equipment and an alarm system (if radio equipment is not available to all staff working in storage areas). **Spill control equipment (e.g., sorbent pads) will be available in all waste storage areas, and where liquids are transferred from one vessel to another.**

Security will be provided for hazardous waste accumulation areas. In general, a barrier such as barricade tape or temporary fencing will be provided for hazardous waste accumulation areas and for accumulation areas that are accessible to the general public. Additionally, signs will be posted at all unmanned operations and maintenance (O&M) sites and/or waste accumulation areas identifying appropriate JV-II personnel and phone numbers to contact in an emergency.

6.2.6 Waste/Fuel Storage Area Inspections

Areas and containers used for waste management and fuel storage will be inspected for evidence of malfunctions, deterioration, discharges, and leaks that could result in a release. The following inspection schedule will be followed:

- **Weekly** inspection of containers, tanks and roll-off boxes (for leaks, signs of corrosion, or signs of general deterioration).
- **Weekly** inspection of stockpiles (for liner and berm integrity).
- **Weekly** inspection of fuel storage areas (e.g., signs of eroding containment systems and rusting tanks/ancillary equipment).

If operations are suspended such that waste storage areas cannot be inspected weekly, all hazardous, free-product, and -contaminated wastes will be removed from the site. Inspections will be recorded in the Contractor Quality Control Report, with copies of the report maintained onsite and available for review.

6.3 Transportation

Each transportation vehicle and load of waste will be inspected before leaving the site. The quantities of waste leaving the site will be recorded. A contractor licensed for commercial transportation will transport non-hazardous wastes. In the event that wastes are hazardous, the transporter will be licensed in accordance with 49 CFR 171-179. A copy of the documentation indicating that the selected transporter has the appropriate licenses will be received prior to transport of any waste material.

6.3.1 Manifests/Shipping Documentation

Each load of waste material will be manifested prior to leaving the site. At a minimum, the manifest form will include the following information:

- Transporter(s) information including name, address, and phone number
- Generator information including name, address, contact, and phone number
- Site name including street/mailing address (if different from generator address)
- Designated disposal facility name, address, and phone number
- Description of waste (reference profile or approval number)
- Type of container (DM=Metal drums, barrels, kegs; DW=Wooden drums, barrels, kegs; DF=Fiberboard or plastic drums, barrels, kegs; TP=Tanks portable; TT=Cargo

tanks (tank truck); TC=Tank cars; DT=Dump truck; CY=Cylinders; CM=Metal boxes, cartons, cases (including roll-offs); CW=Wooden boxes, cartons, cases; CF=Fiber or plastic boxes, cartons, cases; BA=Burlap, cloth, paper or plastic bags)

- Quantity of waste (volumetric estimate in gallons for liquids or cubic yards for bulk solids)
- Additionally, each shipment of waste will also have a waste profile (reviewed and approved prior to off-site transport), **a Land Disposal Restriction Notification/Certification for hazardous wastes**, and a haul ticket.

6.3.2 Waste Shipment Tracking and Exception Reporting

If the signed hazardous waste manifest from the designated offsite facility is not received within 35 days, JV-II will contact the transporter or the designated facility to determine the status of the waste. If the signed hazardous waste manifest has not been received within 45 days, JV-II will prepare an "Exception Report" for the Navy to submit to the State of Florida, as required under 40 CFR 262.42.

6.3.3 Transporter Responsibilities

In general, the transporter will be responsible for weighing loads at a certified scale. For each load of material, weight measurements will be obtained for each full (gross) and empty (tare) container, dump truck, or tanker truck. Disposal quantities will be based on the difference of weight measurements between the full and empty container, dump truck, or tanker truck (net weight). Weights will be recorded on the waste manifest if no volumetric estimate has been made. The transporter will provide copies of weight tickets with the final manifest to JV-II.

The transporter will observe the following practices when hauling and transporting wastes offsite:

- Minimize impacts to general public traffic.
- Repair road damage caused by construction and/or hauling traffic.
- Cleanup material spilled in transit.
- Line and cover trucks/trailers used for hauling contaminated materials to prevent releases and contamination.
- Decontaminate vehicles/trailers prior to re-use, unless dedicated to hauling contaminated material from the same project site.
- Seal trucks transporting liquids

No materials from other projects will be combined with materials from NTC Orlando.

All personnel involved in offsite disposal activities will follow safety and spill response procedures outlined in the Health and Safety Plan..

6.3.3.1 Spill Reporting

In the event of a spill or release of any waste, the transporter must immediately notify JV-II. The pertinent facts and information about the spill will be reported to JV-II and recorded, including:

- Type of material (e.g., soil, sludge, water) and contaminant(s)
- Location
- Estimated volume
- Media affected (e.g., spilled on concrete pad or soil)
- Time of spill/release
- Initial response actions taken
- Final disposal of spilled material

The transporter will also report any spill or release of hazardous waste, as required by 49 CFR 171.15, to the National Response Center (NRC) at 800-424-8802 or 202-426-2675. The transporter must also report in writing, as required by 49 CFR 171.16, to the Director, Office of Hazardous Materials Regulations, Materials Transportation Bureau, Department of Transportation, Washington, DC 20590.

For any spill of hazardous waste water from a bulk shipment (e.g., tanker), the transporter will immediately notify the NRC (800-424-8802 or 202-267-2675), as required under 40 CFR 263.30.

6.3.3.2 Spill Response

The transporter will clean up any spill or release of waste (including soil or water) that occurs during transportation, or take such action as may be required or approved by Federal, State, or local officials. Spilled waste will be immediately cleaned up, including soils on the outside of the trucks or other container (e.g., rail car) and on the ground or road surface. Where appropriate, the spilled material (e.g., soil), will be returned to the original waste container. In any case the spilled material will be properly contained and disposed.

6.3.4 Transportation and Disposal Log

Transportation of wastes will be inventoried the day of transportation from the site using the Transportation and Disposal Log. A copy of the initial manifest form for each load will be retained on-site and attached to the Daily Production Report. All required transportation manifests will be prepared by JV-II and signed by an NTC Orlando representative.

6.4 Offsite Disposal of Waste Streams

Offsite treatment or disposal facilities will use the waste profile and supporting documentation (e.g., analytical data) to determine the acceptability of a waste.

- Hazardous wastes will be sent to a permitted, RCRA Subtitle C treatment, storage, or disposal (TSD) facility.

- Non-hazardous, contaminated wastes such as petroleum-contaminated soil will be disposed at a RCRA Subtitle D facility permitted to receive such wastes.
- Aqueous wastes will be disposed offsite at a facility permitted to accept the waste (e.g., aqueous hazardous wastes to a Subtitle C facility).
- Uncontaminated construction debris may be sent to municipal landfills, or landfills designated for construction and demolition (C&D) debris. The treatment or disposal facility will be responsible for providing a copy of the final waste manifest and a certificate of treatment or disposal for each load of waste received.

6.5 Training

Training requirements for onsite personnel are provided in the site-specific health and safety plan.

6.6 Records/Reporting

The following records and documents will be maintained:

- Transportation and offsite disposal records, including:
  - Profiles and associated waste characterization data
  - Manifests, Land Disposal Restriction notifications/certifications, bills of lading, and other shipping records, e.g. weight tickets
  - Offsite facility waste receipts, certificates of disposal/destruction
- Training records
- Inspection records

The JV-II will maintain MSDS for chemicals and/or hazardous materials brought onsite.

7.0 Environmental Protection Plan

The Environmental Protection Plan provided in the Basewide Work Plan provides general information on the appropriate requirements to be adhered to during the performance of the work at former NTC Orlando. The following information is supplemental and specific to sub-surface injection/aquifer remediation activities.

7.1 Regulatory Drivers

Remedial activities at SA 17 are conducted under the provisions of the following:

- Wastes generated during the remedial activities at former NTC Orlando will be managed consistent with State of Florida hazardous waste generator provisions for large quantity generators (FAC 62-730), and the requirements of FAC Chapter 62-777 (Contaminant Cleanup Target Levels).
- Florida Department of Environmental Protection
- Environmental Protection Agency (EPA) 40 CFR 261 (Identification and Listing of Hazardous Waste)

7.2 Spill Prevention and Control

The provisions for spill prevention and control establish minimum site requirements. Subcontractors are responsible for spill prevention and control related to their operations. Subcontractors written spill prevention and control procedures must be consistent with this plan. All spills will be reported to the JV-II site supervisor and/or project manager. Refer to the Health and Safety Plan, Appendix B for emergency response procedures and further reporting requirements.

7.3 Spill Prevention

All fuel, chemical, and waste storage areas will be properly protected from on- and offsite vehicle traffic. All tanks (including fuel storage and waste storage) must be equipped with secondary containment. These tanks must be inspected daily for signs of leaks. Accumulated water must be inspected for signs of contamination (e.g., product sheen, discoloration, and odor) before being discarded. Fire protection provisions outlined in the Health and Safety Plan (Appendix B) and in subcontractor work plans must be adhered to.

Chemical products must be properly stored, transferred, and used. Should chemical product use occur outside areas equipped with spill control materials, adequate spill control materials must be maintained at the local work area.

7.4 Spill Containment and Control

Spill control materials will be maintained in the support zone, at fuel storage and dispensing locations, at injection areas, and at waste storage areas. Incidental spills will be contained using sorbent materials; once used, spent sorbents will be containerized and disposed of properly. Spilled materials must be immediately contained and controlled. Spill response procedures include:

- Immediately warn any nearby workers and notify supervisor.
- Assess the spill area to ensure that it is safe to respond.
- Evacuate area if spill presents an emergency.
- Ensure any nearby ignition sources are immediately eliminated.
- Stop source of spill.
- Establish site control for spill area.
- Contain and control spilled material through use of sorbent booms, pads, or other materials.
- Use proper PPE in responding to spills.

7.5 Spill Cleanup and Removal

All spilled material, contaminated sorbent, and contaminated media will be cleaned up and removed as soon as possible. Contaminated spill material will be drummed, labeled, and properly stored until material is disposed of. Contaminated spill material will be managed as waste (see Section 4.0 Waste Management Plan) and disposed of according to applicable, federal, state, and local requirements.

7.6 Endangered Species Protection

According to the US Fish and Wildlife Service (USFWS), North Florida Field Office, as of February 16, 2005 no federally listed mammals, fish, amphibians, mollusks, or crustaceans were known to be present in Orange County. Bird species present in Orange County and listed as threatened include Audubon's Crested Caracara (*Polyborus plancus audubonii)*, Bald Eagle (*Haliaeetus leucocephalus)*, Piping Plover (*Charadrius melodus)*, and Florida Scrub Jay *(Aphelocoma coeruluscens).* Bird species present in Orange County and listed as endangered include the Wood Stork *(Mycteria americana)* and the Red-Cockaded Woodpecker *(Picoides borealis).*

Reptile species present in Orange County and listed as threatened include the Sand Skink *(NEOS®eps reynoldsi)* and the Eastern Indigo Snake *(Dymarchon corais couperi).* No endangered reptile species are known to be present in Orange County.

Threatened plant species known to be present in Orange County include the Florida Bonamia *(Bonamia grandiflora)* and the Papery Whitlow-wort *(Paronychia chartacea* = *Nyachia pulvinata)*. Endangered plant species known to be present in Orange County include Britton's Beargrass *(Nolina brittoniana)*, Scrub Lupine *(Lupinus aridorum)*, Beautiful Pawpaw *(Deeringothamnus pulchellus)*, Sandlace *(Polygonella myriophylla)*, and Scrub Wild Buckwheat *(Eriogonum longifolium* var. *gnaphalifolium)*.

Based on available background information, no endangered species are known to be present in areas that will be disturbed by construction activities at SA 17.

7.7 Environmental Protection/Erosion Control

During those excavation activities that have the potential to disturb the land, JV-II will adhere to the following practices:

- The smallest practical area will be disturbed.
- Trees will be protected from any construction activity. No ropes, cables, or guy lines will be fastened or attached to any existing trees.
- Temporary erosion and sediment controls will be used during excavation to prevent sediment from discharging to the drainage swale south of the TTZ-1. Structural controls may include the use of straw bales, silt fences, earthen dikes, drainage swales, sediment traps, and sediment basins.

Material staging areas will be properly barricaded for containment and to control run-off.

Figure 2-1 shows the general layout of erosion control measures at the site.

7.8 Underground Injection Control

Applicable UIC regulations are listed at Rule 62-528, FAC (Underground Injection Control); specifically, Part V – Criteria and Standards for Class V Wells and Part VI – Class V Well Permitting.

In a letter dated May 20, 2005 from Mr. Rick Ruscito, P.E. and Rebecca Lockenbach of the Bureau of Petroleum Storage Systems, FDEP, to Mr. Gary Birk of EOS® Remediation, Inc., the agency and regulatory requirements for performing EOS®injections at remediation sites in Florida were outlined. The letter states that "the issuance of a site-specific remedial action plan approval order by the FDEP, for remediation via injection of EOS® into an aquifer, constitutes the granting of the state's permit for a Class V Injection Well."

In addition, for FDEP acceptance of the use of EOS® as a product for in-situ anaerobic bioremediation and the allowance of a zone of discharge by Rule 62-522.300(2)(c) F.A.C, the following conditions need to be addressed in a Remedial Action Work Plan which has to be accepted by FDEP:

a) Identification of the chemical species contained in EOS® that will be introduced into the subsurface via the injection well, namely Polysorbate 80, TRPH, sodium, total dissolved solids, chloride (if significant amounts of this degradation byproduct will be generated) and bromide (if a tracer is being used). For this RA, sodium bromide tracer will be used; therefore, bromide will be included in the list of groundwater parameters to be monitored.

b) Indication of the size and duration of the temporary ZOD of EOS®. For this RA at SA 17, the size of the ZOD will be an area 50 feet wide and 50 feet long, to a depth of approximately 50 feet bls. The actual duration of the EOS® discharge into the aquifer is expected to be approximately 21 days.

c) Address groundwater monitoring of these parameters before and after injection. The ZOD will be monitored prior to introduction of EOS® into the aquifer as part of a baseline sampling and analysis event, and monitored initially on a quarterly basis for a year after EOS® injections, with the parameters named in a) above included in a more extensive list of groundwater parameters which will be analyzed at an offsite laboratory.

7.9 Environmental Conditions Report

JV-II and the Resident Officer in Charge of Construction (ROICC) or NTR will conduct an environmental conditions survey for each project site prior to the commencement of construction. The pre-construction condition of the facilities, including grassy areas, trees, shrubs, paving, gutters, curbs, buildings, and facilities, will be photographed. A written report describing the pre-construction condition of the project site, including copies of the photographs and comments on the condition of existing paved areas, will be submitted to the ROICC within two (2) weeks from the construction start date.

8.0 Stormwater Pollution Prevention Plan

8.1 Applicable Regulations

Federal law at 40 CFR Part 122 prohibits the point source discharge of pollutants, including the discharge of stormwater associated with large construction activities as defined at 40 CFR 122.26(b)(14)(x) or small construction activities as defined at 40 CFR 122.26(b)(15), to waters of the United States without a National Pollutant Discharge Elimination System (NPDES) permit. Under the State of Florida's authority to administer the NPDES stormwater program at 403.0885, F.S., operators that have stormwater discharge associated with large or small construction activities to surface waters of the State, including through a Municipal Separate Storm Sewer System (MS4), must obtain coverage either under a generic permit issued pursuant to Chapter 62-621, FAC, or an individual permit issued pursuant to Chapter 62-620, FAC.

8.2 Relevance of Applicable Regulations to SA 17, NTC Orlando

In accordance with the definitions provided at Rule 62-621.300(4), (FAC, anticipated JV-II work activities at the former NTC Orlando will not disturb an area exceeding one acre and hence do not meet the definition of "small construction activities" (area of disturbance greater than one acre and less than five acres). In addition, the activities at the former NTC Orlando do not constitute part of a larger common plan of development or sale that will ultimately disturb equal to or greater than one acre and less than five acres and the filing of a Notice of Intent (NOI) to discharge stormwater from the site is not necessary.

9.0 Quality Control Plan

The quality control plan provided in the NTC Orlando Basewide Work Plan (CH2M HILL, 1998) details the quality administrators, presents the approach to performing construction inspections, and discusses the overall approach for implementing the site QC requirements at NTC Orlando. This construction quality control plan discusses the definable features for the EOS® recirculation effort at SA 17.

9.1 QC Organization

The project organization for the SA 17 site remediation under TO 0006 is shown on Figure 9-1. The Project Manager and Project QC Manager are assigned overall responsibility for the implementation and enforcement of this quality control plan. The Site Superintendent will assume responsibility for executing the work activities described in the overall work plan.

9.2 Names and Qualifications

Mr. Eric Burrell will be the Project QC Manager. The resume for Mr. Burrell is attached in Appendix D.

9.3 Duties, Responsibilities and Authority of QC Personnel

Individual roles and responsibilities of task order personnel are summarized in Table 9-1. The responsibilities of the key members in the project organization are described below.

9.3.1 Project Manager

The Project Manager is responsible for the overall direction of the task order executed under his supervision. He provides the managerial and administrative skills to ensure that resource allocation, planning, execution, and reporting meet contract and task order requirements. He is ultimately accountable for all work activities undertaken on this project. The global quality-related responsibilities of the project manager can include, but are not limited to, the following:

- Organize of the project staff and assignment of responsibilities
- Understand of contract and scope of work for the specific project
- Communicate to the project staff regarding client requirements and QA/QC practices
- Identify, document, and notify the client and project team of changes in the scope of work, project documentation and activities

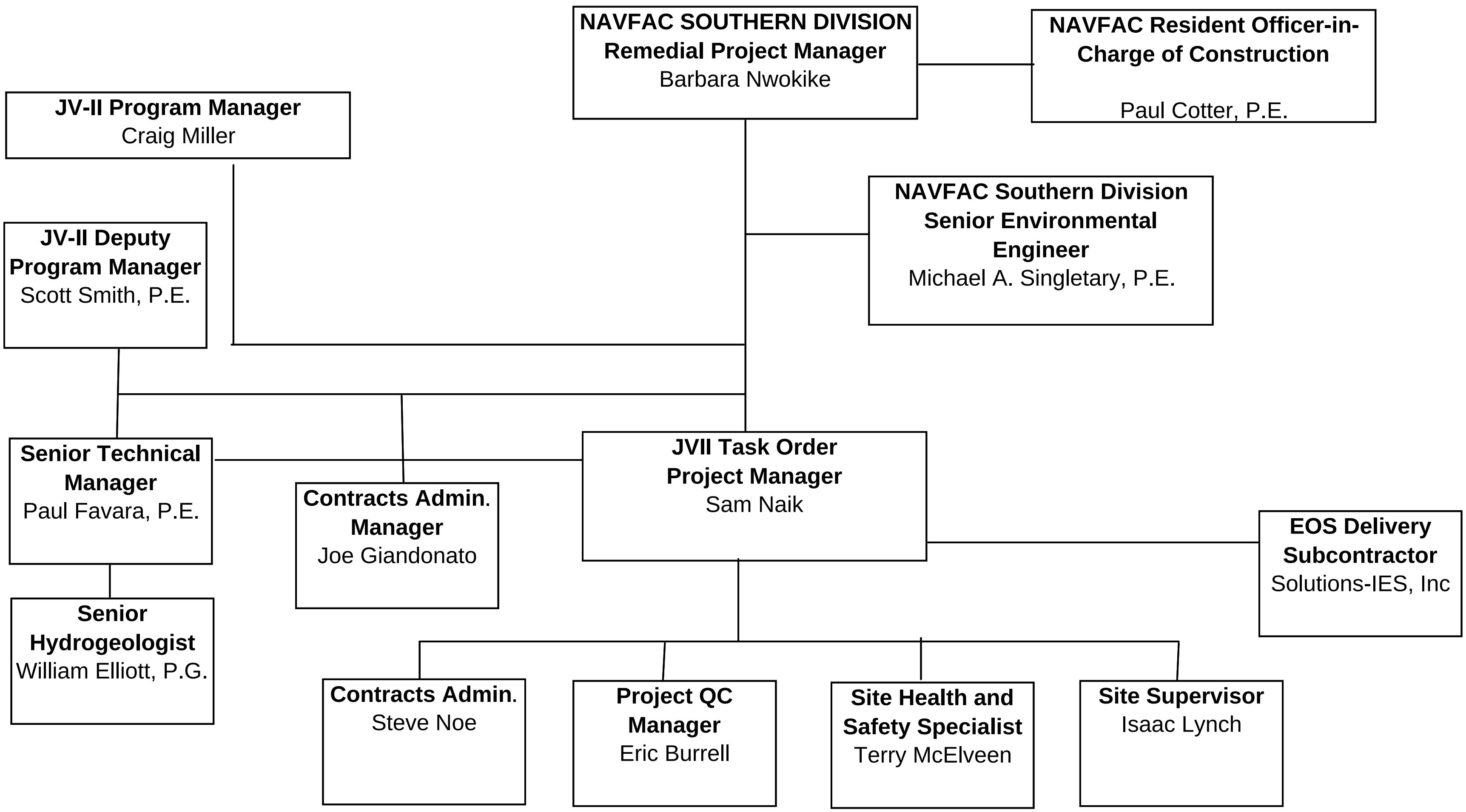


Figure 9-1 Project Organizational Chart, SA 17, NTC Orlando, Florida

- Supervise preparation and approval of project-specific procedures, work plans, and QA project plans
- Approve of project design bases, design parameters, drawings, and reports
- Approve of project construction methodologies
- Disseminate project-related information from the client such as design bases, input parameters, and drawings
- Serve as liaison for communications with the client and subcontractors
- Serve as liaison between the project staff and other internal groups
- Determine whether or not drawings require independent review
- Investigate nonconformance and implementation of corrective actions
- Determine the effect of nonconformance on the project and the appropriateness for reporting such items to the client, and providing appropriate documentation for reporting
- Verify that changes, revisions, and rework are subject to the same QC requirements as the original work
- Serve as final reviewer prior to release of project information
- Approve and sign outgoing correspondence

Some of these responsibilities may be delegated by the Project Manager to the Site Superintendent, who will remain onsite for the duration of project field activities.

9.3.2 Site Superintendent

The Site Superintendent is responsible for the day-to-day management of this specific task order. He will ensure sufficient resource allocations to maintain project schedule and budget. He will provide daily feedback to the Project Manager on project progress and the status of any issues requiring resolution, comment, or action on the part of the Project Manager. The quality-related responsibilities of the site superintendent include, but are not limited to, the following:

- Notify the project manager if the project cannot be completed with regard to quality, schedule, or cost
- Provide oversight and control of self-performed and subcontracted services
- Serve as liaison for communications with project staff and subcontractors, as well as with the Navy and Base representatives
- Supervise day-to-day site activities in accordance with project and program requirements
- Initiate corrective actions for non-conformance identified onsite

9.3.3 Senior Technical Manager

The Senior Technical Manager is responsible for identifying the appropriateness of the remedial technology selected for the project, and evaluates the site history, current site conditions and implementability of the selected remedial technology. The Senior Technical Manager's duties include oversight of the Optimization Studies in accordance with the Navy Optimization guidance documents, identification of appropriate short-term and long-term treatment monitoring schemes and addressing appropriate regulatory issues surrounding the identified remedial technology. The Senior Technical Manager will also review and guide the preparation of project technical work plans and project completion reports and supervise the technical staff on technical issues of the project. The Senior Technical Manager will be a Professional Engineer licensed by the State of Florida and will have the appropriate educational background and training to supervise the technical aspects of the implementation of the chosen remedial technology.

9.3.4 Senior Hydrogeologist

The Senior Hydrogeologist is responsible for studying the hydrogeologic and lithologic information for the site and to evaluate the adequacy of available site-specific subsurface hydraulic, geological and contaminant information to aid in the design and operation of the chosen remedial technology. The Senior Hydrogeologist is also responsible to address details concerning additional site-specific tests such as aquifer pump tests, well construction methods, well filter-pack design and specifications. The Senior Hydrogeologist will also help develop the scope of work for the well installation contractor, provide supervision to junior technical staff and provide field oversight during well installation, well development, logging lithological information during well installation, preparation of well construction diagrams and well boring logs, and review technical work plans and completion reports. The Senior Hydrogeologist will be a Professional Geologist licensed by the State of Florida and will have the appropriate educational qualifications and training to supervise the relevant technical aspects of the project pertaining to his/her field of expertise.

9.3.5 Project QC Manager

The Project QC Manager is responsible for the execution of the project's construction quality control system and communicates the on-site QA program policies, objectives and procedures to project personnel and Subcontractors during project meetings and informal discussions. Onsite technical personnel, which include a Construction QC Manager, engineers, chemists, hydrogeologists, and scientists, will assist the Project QC Manager in monitoring, controlling, and documenting the quality of the onsite construction, survey, sampling, and remedial activities. All documentation related to project QC, including analytical test results, inspections, material test results, and audits will be reviewed or prepared by the Project QC Manager. The Project QC Manager's duties include the following:

- Three phases of control inspections
- Control testing
- Document control
- Review of Submittals

- Completion inspection
- Records
- Audits and surveillance

The Project QC Manager will also coordinate with and assist Navy representatives in the performance of QA audits and inspections.

9.4 Outside Organizations and Subcontractors

JV-II assumes overall responsibility for ensuring conformance of subcontracted materials and services to quality requirements. However, it is the responsibility of the subcontractor to plan, manage, and accomplish the treatment activities in accordance with the plans, specifications, and local, state and federal regulations.

Subcontractors include those organizations supplying materials or services to the project. Subcontractors report directly to the Site Superintendent and are responsible for completion of the project-specific activities assigned. Subcontractors are also responsible for meeting the quality requirements for the materials and workmanship as defined by the Project QC Manager. Subcontractors will verify that construction activities and materials comply with the requirements of the contract plans and specifications.

Services/materials anticipated to be subcontracted for the SA 17 project include:

- Well Installation Subcontractor
- Surveying Subcontractor
- Treatment Technology Subcontractor
- Environmental Laboratory
- Waste Transporter
- Waste Disposal Facility

TABLE 9-1
Roles, Responsibilities, and Authority of QC Personnel Assigned to NTC Orlando

Role	Responsibility	Authority
Project Manager	• Management and Technical Direction of work • Communication with Southern Division RPM and NTR • Overview subcontract task order performance • Select task order staff • Develop task order Work Plan and supporting plans • Meet task order Performance Objectives • Prepare status reports • Prepare Field Change Requests	• Approve subcontract task order selection • Approve invoices to Southern Division • Approve TASK ORDER baseline schedule • Stop work at the site for any reason • Approve payment to vendors and suppliers • Approve payment to subcontractor • Review technical qualifications of subcontractor • Respond to Design Change Notices
Site Superintendent	• Responsible for all site activities • Provide direction to subcontractor • Act for Project Manager • Provide daily status reports • Prepare task order Work Plan • Conduct daily safety meetings • Review subcontractor qualifications • Stop work for unsafe conditions or practices	• Stop work for subcontractor • Approve corrective action for site work-arounds • Approve materials and labor costs for site operations • Resolve subcontractor interface issues • Approve daily and weekly status reports
Senior Technical Manager	• Evaluate and recommend appropriate remedial technology • Supervise preparation of Optimization Studies and select most suitable remedial technology for remedial action at the site. • Communicate with Technical Branch of the Navy and with specialty subcontractors on RA design and implementation details.	• Supervise, review and approve design of remedial technology application, remedial action project work plans and post-RA site monitoring.
Senior Hydrogeologist	• Evaluate site subsurface geological and hydraulic characteristics and applicability of selected remedial technology against site conditions. • Develop site-specific information to assist Senior Technical Manager in evaluating applicability of chosen remedial action technology for the site. • Prepare scope of work for well installations and evaluate bid submittals from well drillers.	• Select well installation subcontractors based on technical merit, past performance and price. • Supervise junior geologists and site supervisor on all aspects of well installation including proper well installation, well completion and development methods, and wellhead completions. • Supervise and conduct aquifer pump tests, and provide conclusions and relevance of results of the pump test to the project team.
Project QC Manager	• Monitor and oversee task order compliance with scope of work • Review requests for changes in scope of work • Recommend improvements in work techniques or metrics	• Complete daily compliance report • Monitor and report on subcontractor quality and quantities • Audit subcontractor offsite fabrication • Maintain Submittal Register

TABLE 9-1
Roles, Responsibilities, and Authority of QC Personnel Assigned to NTC Orlando

Role	Responsibility	Authority
	• Recommend work-around to Site Superintendent • Monitor and report on subcontractor quality and quantities • Audit subcontractors offsite fabrication • Maintain Submittal Register • Participate in Incident-Free Operations conference call	• Stop work for non-compliant operations • Maintain Rework Items list • Stop work for non-compliant operations
Site Health and Safety Specialist	• Monitor and report on subcontractor safety and health performance • Record and report safety statistics • Conduct required site safety and health orientation • Maintain Environmental Log • Stop work for unsafe practices or conditions	• Stop work for unsafe practices or conditions • Approve subcontractor site specific health and safety plan • Set weekly safety objectives • Approve resumption of work for resolved safety issues
Subcontract Specialist	• Prepare bid packages • Purchase disposable materials • Maintain subcontract log • Approve payables for disposable items • Maintain government property records	• Provide project scheduling coordination • Responsible for site cost tracking and reporting • Maintain record of site purchases
Solutions-IES, Inc. (EOS® delivery subcontractor)	• Provide technical and cost information on EOS® product and its application at the SA-17 site. • Provide necessary design drawings to indicated method of EOS® recirculation and details of associated equipment. • Arrange for labor, materials and equipment to conduct EOS® recirculation per RAWP and design drawings.	• Supervise Solutions-IES field personnel in the conduct of their scope of work. • Provide timely updates of cost and technical milestones reached.

9.5 Submittal Procedures and Initial Submittal Register

As required by this Task Order, JV-II will follow the procedures relative to submittals to the government as defined in the contract documents. Each submittal will include a transmittal form properly identifying each submittal. The Project QC Manager is responsible for the completeness and accuracy of all submittals and will be assisted in this task by the Project Manager.

The Project QC Manager will review submittal packages in detail for completeness and compliance with contract requirements for documentation. In addition, the Project QC Manager will certify each submittal. Exceptions must be noted and expressly stated. This procedure will ensure that field data are adequate for the intended use and meet contract requirements. Each member of the project QC team in the chain of command is responsible for preparation and review of pertinent QC material and field log documents.

The Site Superintendent will document daily field activities and safety procedures and submit the appropriate documentation to the Project QC Manager for organization and review. The Project QC Manager will complete the review and submit the information to the Project Manager. Following a final review and organization by the Project Manager, applicable data and information relating to overall project quality control will be forwarded to the Navy. The Project Manager has the authority to sign submittals and present them to the government or reject the documents and have them returned to the project team or subcontractor for revision.

The Submittal Register, provided in Appendix B of this Work Plan, documents submittals in accordance with the JV-II contract. JV-II, the Navy, or others will approve submittals as identified in the submittal register. All approved submittals will be distributed by JV-II to the appropriate Navy and former NTC Orlando personnel (CO, ROICC (in duplicate), etc.), the project site, and to the project file.

9.6 Testing Laboratory Information

Laboratories performing testing or analysis of materials and environmental samples, or craftsmen performing independent testing will be certified or qualified to perform the respective testing. This section summarizes the onsite field testing planned for the project. Samples of media requiring definitive chemical analysis will be performed by an approved offsite laboratory.

9.6.1 Chemical Testing Laboratory

The environmental testing laboratories utilized for this task order project will function as a Subcontractor or a lower-tier Subcontractor. Laboratories performing analysis of environmental samples will be those that have previously performed or are currently performing analysis in support of the Navy's IRP per the Navy's IR CDQM FESC SP-2056-ENV, September 1999. Laboratories will have undergone the laboratory approval process as defined in the subject NFESC document for the scope of work performed under the IRP.

9.7 Testing Plan and Log

The general testing requirements are shown in Table 9-2.

TABLE 9-2
Testing Requirements

Test/Inspection	Requirement/Reference	Frequency
Chemical Testing of Soil and Groundwater	Sampling And Analysis Plan and Waste Management Plan	As per Sampling And Analysis Plan and Waste Management Plan
Treatment System Equipment Startup and Testing	See Section 4.0, Remedial Action Construction	
Field Surveying	Horizontal – Mercator Projection, GRS 80, State Plane Coordinate System, North American Datum	Locate injection, extraction, and monitoring wells, monuments, control

TABLE 9-2
Testing Requirements

Test/Inspection	Requirement/Reference	Frequency
	1983, Lambert Zones 1-6, feet; Vertical – Mean Sea Level (msl), North American Vertical Datum, 1988, feet; Vertical tolerance +/- 4 inches, field measurements recorded to nearest 10^{th} of a foot	points, and significant site features

The Testing Plan and Log (Appendix C) will used to record the results of field testing. Detailed records of testing will be included in the daily contractor quality control report (CQCR).

9.8 Procedures to Complete Rework Items

The rework items list is intended to identify and status those items of work within the task order that have been identified as not satisfying contract requirements. The list will be developed and maintained at the site by the Project QC Manager. The daily CQCR makes provisions for reporting rework items identified during initial and follow-up phases of control construction inspections. Rework items identified as a consequence of testing will be discussed during meetings, at which time resolution of the nonconformity will be planned and agreed upon.

9.9 Documentation Procedures

The Basewide Work Plan provides the details of the documentation procedures. Over the course of executing the work described in this work plan, JV-II will deliver the following documentation:

- Contractor Quality Control Report
- Contractor Production Report (CPR)
- Preparatory Phase Checklist
- Initial Phase Checklist
- Field Test Reports
- Monthly Summary Report of Field Tests
- Testing Plan and Log
- Rework Items List
- QC Meeting Minutes
- QC Certifications

The documentation will generally be submitted as an attachment to the CQCR. During the coordination and mutual understanding meeting, the exact details of reporting (frequency, due dates/times, internal/external distribution, etc.) will be discussed.

9.10 List of Definable Features of Work

The Project QC Manager will perform inspections of the materials, equipment, and overall work activities. The inspections are performed to ensure that safe, efficient, and high quality work is performed, while meeting the objectives and requirements of the plans and specifications.

The project tasks for this Task Order are grouped into definable features of work (DFOW), which are work activities with individual plans and specifications. The definable features of work for this project are:

- Mobilization and Site Preparation
- Site Surveying
- Installation of Injection and Extraction Wells
- Installation of Temporary Aboveground Piping and Appurtenances
- Treatment system startup, testing and optimization
- Full-scale operation of the EOS® Recirculation System
- Site restoration
- Field sampling
- Waste management
- Decontamination and demobilization

9.11 Procedures for Performing the Three Phases of Control

The definable features will be inspected in accordance with the three phases of control. The three phases include preparatory, initial, and follow-up. The BWP provides discussions of how the three phases of control will be implemented. An overview of the inspection provisions is outlined in the subsections that follow.

Environmental samples will be collected in accordance with USEPA methods and procedures. Other controls will include, but are not limited to, maintaining a chain of custody; using proper handling, packaging, and shipping methods to preserve sample integrity; using qualified laboratories; and completing independent reviews of laboratory results using a qualified scientist employed by JV-II.

The construction controls include review of project drawings, work plans, associated specifications, and other project related documents. Prior to commencing any DFOW, a preparatory phase meeting will be conducted to review the testing requirements, work scope details, procurement, schedule and applicable health and safety considerations or requirements.

The Project QC Manager will verify the following items:

- Facilities and testing equipment are available and comply with testing standards

- Contract drawings are updated with utility locations and as-built drawings are accurate

- Recording forms, including all of the testing documentation requirements, have been prepared
- Required material certificates (piping, well construction materials, etc.) are received and acceptable

9.11.1 Mobilization and Site Preparation

Mobilization will take place in phases consistent with the activities shown on the project schedule. Personnel, subcontractors, equipment, and materials will be mobilized based on the scope of the activity. Initially, the approximate boundary of the contaminated plume (including the TTZ-1) and any designated waste staging areas will be mapped based on the plan drawings and specifications.

As part of the mobilization activity, a pre-construction meeting will be held to review preparedness, the overall project scope and schedule, communications, and reporting. The preparedness check will confirm that site preparation requisites such as permitting/approvals, utility clearances, demarcating of work zones, and staging of equipment and material, as necessary, are in place to begin the work activities.

Preparatory Phase

The preparatory phase will include a review of the relevant activity hazard analysis (AHA) process and the daily tailgate safety meeting, the project work plan, communications matrix, project schedule, submittal status, and confirmation of appropriate materials and equipment. The locations planned for installation of stormwater and erosion controls will be discussed. An Environmental Conditions Report (ECR) will be prepared by the field personnel to record the site conditions prior to commencement of field activities.

Initial Phase

Inspections will be made as necessary to ensure construction limits are defined, utilities marked, and material staged in the designated areas.

Follow-up Phase

The Project QC Manager will provide continuous oversight of the site preparation activities to verify that the work is completed in accordance with the requirements provided in this work plan. Inspections required by the stormwater and erosion control plan will be performed. Any deficiencies identified will be noted, corrected, and documented as soon as practicable.

9.11.2 Site Surveying

A professional land surveyor registered in the state of Florida will conduct surveying. Initially, the limits of the injection and extraction well installations (well points) will be mapped to allow this activity to commence. Once the well installations are performed, JV-II will map the locations of the wells using a GPS receiver equipped with a range finder. Coordinates for the center points of wells are derived from NTC Orlando EGIS. The well locations will be marked with labeled pin flags. The registered land surveyor, who will also generate record as-built drawings, will later survey the well locations and elevations of top of casing of wells. No other permanent site features, with the exception of any utilities located during the utility clearance or utilities known to be present at the site, will be surveyed. The Site Superintendent is responsible for verifying conformance of final lines and grades with the Contract Documents, and coordinating confirmation with the Project QC manager.

All survey data must conform to the Tri-Service Spatial Data Standards (TSSDS). Horizontal controls for graphic and non-graphic information are Mercator Projection, GRS 80, State Plane Coordinate System, North American Datum 1983, Lambert Zones 1 through 6 (or appropriate zone for region to be mapped), feet. Vertical controls are msl , North American Vertical Datum 1988.

9.11.3 Injection, Extraction, and Groundwater Monitoring Well Installations

Preparatory Phase

The preparatory phase will include a review of the relevant AHAs, the requirements provided in the work plan, review of the proposed well installation plan and drawing, verification of utility clearance; confirmation of acceptability of well risers, screens, wellhead fittings and other required materials; and confirmation that appropriate equipment (PPE, water handling, etc.) and craft personnel are available to complete the work. The oversight geologist will be identified, and the logistical approach to conducting the soil excavation will be discussed.

Prior to the commencement of any intrusive activity, site controls including construction barricades, roadway signs, and security fencing will be inspected/installed as necessary.

Initial Phase

Prior to well installation activities, the project QC manager will complete the initial inspection to verify that the well installation and development activities are being planned to meet the requirements of the scope of work. Deficiencies will be documented and corrected as necessary.

Follow-up Phase

The project QC manager will be responsible for the overall daily surveillance of the well installation activities. The daily surveillance will verify that the work is being completed according to the work plan provisions as necessary.

9.11.4 Installation of Temporary Aboveground Piping and Appurtenances

Preparatory Phase

The preparatory phase will include a review of the relevant AHAs, the requirements provided in the work plan, review of the proposed PID, confirmation of acceptability of aboveground piping material, connections, tightness of joints against leaking, secondary containment under pipe joints, provisions for spill control measures, wellhead fittings and other required materials; and confirmation that appropriate equipment (PPE, water handling, etc.) and craft personnel are available to complete the work. A leak test of all the fittings will be performed using clean water from the nearby fire hydrant. The fire hydrant will be fitted with a backflow preventer and a pressure regulator prior to discharging water into the aboveground piping.

Initial Phase

Prior to the commencement of the injection and recirculation efforts, the project QC manager will complete the initial inspection to verify that the above piping and fittings are installed, functioning as per the design, and are able to meet the requirements of the scope of work. Deficiencies will be documented and corrected as necessary.

Follow-up Phase

The project QC manager will be responsible for the overall daily surveillance of the injection and re-circulation activities. The daily surveillance will verify that the work is being completed according to the work plan provisions as necessary, the measurement instruments are functioning properly, and that there are no leaks in the system.

9.11.5 Utility Connections

There are no utility connections planned for the process trailer. Power supply will be provided by a generator.

Preparatory Phase

There are no utility connections planned for the process trailer. Power supply will be provided by a generator. The preparatory phase will include a review of the relevant AHAs, review of the safety and adequacy of the electrical connections, grounding and static protection for the fuel supply tank, and adequate safe distances between fuel tank and other potential ignition sources.

Initial Phase

Prior to the commencement of the injection and recirculation efforts, the project QC manager will complete the initial inspection to verify that the generator is functioning as per the design, and are able to meet the requirements of the scope of work. Deficiencies will be documented and corrected as necessary.

Follow-up Phase

The project QC manager will be responsible for the overall daily surveillance of the excavation and backfilling activities. The daily surveillance will verify that the work is being completed according to the work plan provisions as necessary. Attention will be placed on safety and prevention of electrical and flammable hazards.

9.11.6 Recirculation System Startup, Testing and Optimization

Preparatory Phase

The preparatory phase will include a review of the relevant AHAs, the requirements provided in the work plan, adequate functioning of the injection system (dosimeter, EOS® dilution and delivery process), proper functioning of the sample ports located on top of the wellheads of the injection and extraction wells, adequate functioning of the extraction pumps, and instrumentation mounted on the wellheads. Additionally, this phase will ensure that craft personnel trained to run the process trailer are available to complete the work.

Initial Phase

Prior to the commencement of the injection and recirculation efforts, the project QC manager will complete the initial inspection to verify that the above piping and fittings are installed, functioning as per the design, and are able to meet the requirements of the scope of work. Deficiencies will be documented and corrected as necessary.

In an effort to ensure that the performance of the groundwater extraction wells is adequate for the EOS® recirculation effort, the deep extraction well will be installed first, and a continuous lithologic log will be recovered to select the screened interval. This log will be used to confirm the proposed injection and extraction well screen intervals. After installation, the well will be developed by pumping and surging to dislodge and remove fine-grained aquifer material.

During the development process, a step drawdown test will be performed to evaluate the yield of the well. The pumping rate will be varied and the drawdown of the water level in the well will be checked at the various rates to determine the average rate the well can be pumped without creating unacceptable drawdown. The intermediate extraction well will be tested during development in a similar fashion.

Follow-up Phase

The project QC manager will be responsible for the overall daily surveillance of the injection and re-circulation activities. The daily surveillance will verify that the work is being completed according to the work plan provisions as necessary, the measurement instruments are functioning properly, and that there are no leaks in the system.

9.11.7 Full-scale Operation of EOS® Recirculation System

Preparatory Phase

The preparatory phase will include a review of the relevant AHAs, the requirements provided in the work plan, review of adequate functioning of the process trailer equipment, preparations for adherence to safe practices outlined in the HASP, and proper functioning of the extraction and injection system.

Initial Phase

Prior to the commencement of the injection and recirculation efforts, the project QC manager will complete the initial inspection to verify that the aboveground piping and fittings are installed, functioning as per the design, and are able to meet the requirements of the scope of work. Deficiencies will be documented and corrected as necessary.

Prior to beginning EOS® injections, a cone of water table surface depression must be created around the extraction wells to ensure that local hydraulic gradients are influenced to create groundwater flow within TTZ-1 toward the extraction well, and that capture of the EOS® solution within the treatment zone will occur. The extraction wells will be started and adjusted to the design flow rate, and the water generated will be discharged to the onsite storage tank.

Water levels will be frequently measured in the extraction wells so that water level drawdown can be tracked. Based on these measurements, the pump flow rate will be adjusted to maintain the maximum stable drawdown without exposing the pump intake or screen.

Water levels in the new interior monitor wells and the new injection wells will also be measured during pumping at least once per hour for up to 8 hours, until consistent drawdown levels are observed in these wells.

Follow-up Phase

The project QC manager will be responsible for the overall daily surveillance of the injection and recirculation activities. The daily surveillance will verify that the work is being completed according to the work plan provisions as necessary, the measurement instruments are functioning properly, and that there are no leaks in the system.

The interior (sentry) monitor wells 17-MW-56B, 17-MW-56C, 17-MW-57B and 17-MW-57C will be periodically inspected for EOS®. Evidence of the sodium bromide tracer using a colorimetric test strip and a field test for TOC using the field test kit indicated in Table 5-1 will be conducted in addition to verify the appearance of EOS® in the groundwater. Similar evidence will be checked for in the extraction wells to confirm evidence of EOS® breakthrough.

The frequency of inspection for EOS® will be based on the actual pumping rates attained, but will be performed at a minimum of three times per day; once in the morning, once at mid-day, and once at the end of the shift.

Extraction well pumping will continue for at least 4 hours after EOS® breakthrough to maintain optimal gradients for EOS® distribution. After all 18 drums of EOS® have been introduced and breakthrough has occurred, the remaining water in the frac tank will be mixed with the extraction well EOS® discharge water and re-injected.

9.11.8 Site Restoration

Preparatory Phase

The preparatory phase will include a review of adequate completion of injection and recirculation activities prior to commencement of site restoration activities. As part of this phase, an assessment will be performed for adequate protection of waste storage drums from weather exposure until disposal of the drums takes place. Also, plans and preparations for proper disposal of erosion control materials will be assessed.

Initial Phase

Inspections will be made as necessary that all erosion control measures are properly dismantled and disposed of in the proper containers. Any disturbance to the site caused by the staging of the process trailers, fuel tanks, etc., will be repaired and the site restored to its original condition. No tree-clearing or grubbing is anticipated for this project, therefore no re-vegetation is anticipated.

Follow-up Phase

The Project QC Manager will provide continuous oversight of the site restoration activities to verify that the work is completed in accordance with the requirements provided in this work plan. Any deficiencies identified will be noted, corrected, and documented as soon as practicable.

9.11.9 Field Sampling

Preparatory Phase

The preparatory phase for sample collection activities includes a review of the sampling procedures provided in the sampling and analysis plan, verifying acceptance of the selected laboratory, and confirming that the appropriate equipment and materials are available to complete the sampling activities.

Initial Phase

Waste characterization samples will be collected and subsequently analyzed at an approved laboratory in accordance with requirements outlined in the work plan or sampling and analysis plan. Sample collection activities including proper chain-of-custody documentation will follow the protocols outlined in the project specific sampling and analysis plan. Samples will be collected of soil, water and decontamination water.

Follow-up Phase

Sample collection activities will be properly documented throughout each sampling event. Analytical reports from the approved laboratory will be reviewed for accuracy and quality. If required, data validation information from the laboratory will be reviewed to verify discrepancies in the analytical data. JV-II quality assurance personnel will review, validate and tabulate laboratory data and field sampling results.

9.11.10 Waste Management

Preparatory Phase

The preparatory phase for the management of liquid and solids wastes includes a review of the waste management plan included in this work plan, disposal, recycling or treatment facility(s) qualifications, transportation schedule for hauling material offsite, and confirming that the appropriate equipment and materials, such as waste manifests, are available to commence the work activity. Review and acceptance of the waste disposal package by the JV-II waste coordinator is required prior to submitting the package to the Navy for approval. Prior to any work, the relevant AHAs will be reviewed and discussed. Note: all temporary storage containers and transport vehicles will be inspected prior to acceptance onto the project and labeled as appropriate.

Initial Phase

This phase includes inspecting the waste transport vehicles (trucks with lift trucks for picking up waste drums, or tow trucks to transport liquid storage tanks), prior to accepting on the job. Containers used for transporting liquids will be free of liquids or other foreign materials prior to filling. Information provided on the waste manifest must be verified as complete and accurate including, but not limited to, generator name, address and signature, date, type of material being hauled, designated recycling or treatment facility, and volume and/or weight of material. Any discrepancies on waste manifest documents will be corrected.

Follow-up Phase

This phase includes verifying the recycling or treatment facility has accepted and treated the waste material at their facility and has sent the required completed manifest to the generator or the generator's technical representative. Receipt of the certificate of recycling or disposal from the designated facility must be verified, as well as that the invoice is complete and accurate. A field logbook and an electronic log of all transportation and disposal shipments will be maintained. Containers, tanks, and roll-off containers will be routinely inspected for integrity and inventoried. Waste storage areas (including areas with stockpiles, containers, tanks, roll-off containers) visually inspected on a daily basis for releases or signs of corrosion, deterioration or other conditions that could result in a release. These results of all inspections will be documented.

9.11.11 Decontamination and Demobilization

Equipment utilized to perform the injection and recirculation activities will be decontaminated in accordance with the provisions of the site specific health and safety plan. Pre-final inspection of cleanliness will be performed by the site superintendent and the site safety and health specialist. Final equipment inspections will be performed and documented by the project QC manager, or his/her designee.

Equipment and personnel will demobilize from the site following the completion of the work activities identified in this work plan addendum. The project QC manager will verify that the objectives of associated remedial activities have been met. A final inspection will be conducted to verify completion of all project activities. Findings, should any be identified, will be tracked, resolved and documented during a final-final site walk through inspection.

Preparatory Phase

The preparatory phase will include a review of decontamination procedures, the health and safety plan, the Waste Management Plan, and relevant AHAs.

Initial Phase

The site superintendent will perform oversight to confirm that the objectives of the decontamination activities have been met and that the rework items, if any, have been completed to the satisfaction of JV-II and the Navy. The project QC manager will perform inspections to verify and document work efforts.

Follow-up Phase

The project QC manager will provide continuous oversight of the decontamination and demobilization to verify that the work is completed in accordance with the requirements provided in the work plan. Deficiencies will be noted and corrected.

9.12 Procedures for Completion Inspection

Near the completion of definable feature of work tasks or the completion of all tasks associated with the scope of work, the project QC manager will conduct a punch-out inspection of the work items to determine completion status and conformance. A punch list of items will be generated that also includes target dates for resolving any deficiencies. This punch list of items will be attached to the quality control report on the day(s) of performing the inspections. The status of the items will be tracked via follow-up inspections.

The project manager will notify the Navy that the project is ready for a pre-final inspection. The Navy will perform this inspection to determine whether the project is complete and ready for acceptance. Should any items be identified, a punch list of items will be generated and tracked by the project QC manager. Upon satisfactory completion of the punch list, the project manager will notify the Navy that the project is ready for the final inspection.

Advanced notice of at least 14 days will be given to the Navy Contracting Officer of the plan for conducting the final inspection. The status of the punch list items from the pre-final inspection will be reported, and a statement that pending items will be completed prior to the date of the final inspection. The project manager, project QC manager, site superintendent, essential Subcontractor representatives, Navy representative(s) and others as determined by the Navy will attend the final inspection.

10.0 References

CH2M HILL, 1999. NTC Orlando Basewide Work Plan, Revision No. 00

CH2M HILL. 2003. *Construction Documentation Report for the Interim Remedial Action at SA 17.*

CH2M HILL. 2005. *Summary of Data Collection Activities, Study Area SA 17, Former Naval Training Center Orlando.*

CH2M HILL. 2005. *Optimization Report for Study Area 17*, Former Naval Training Center, Orlando

State of Florida, Department of Environmental Protection, FAC Chapter 62-777.

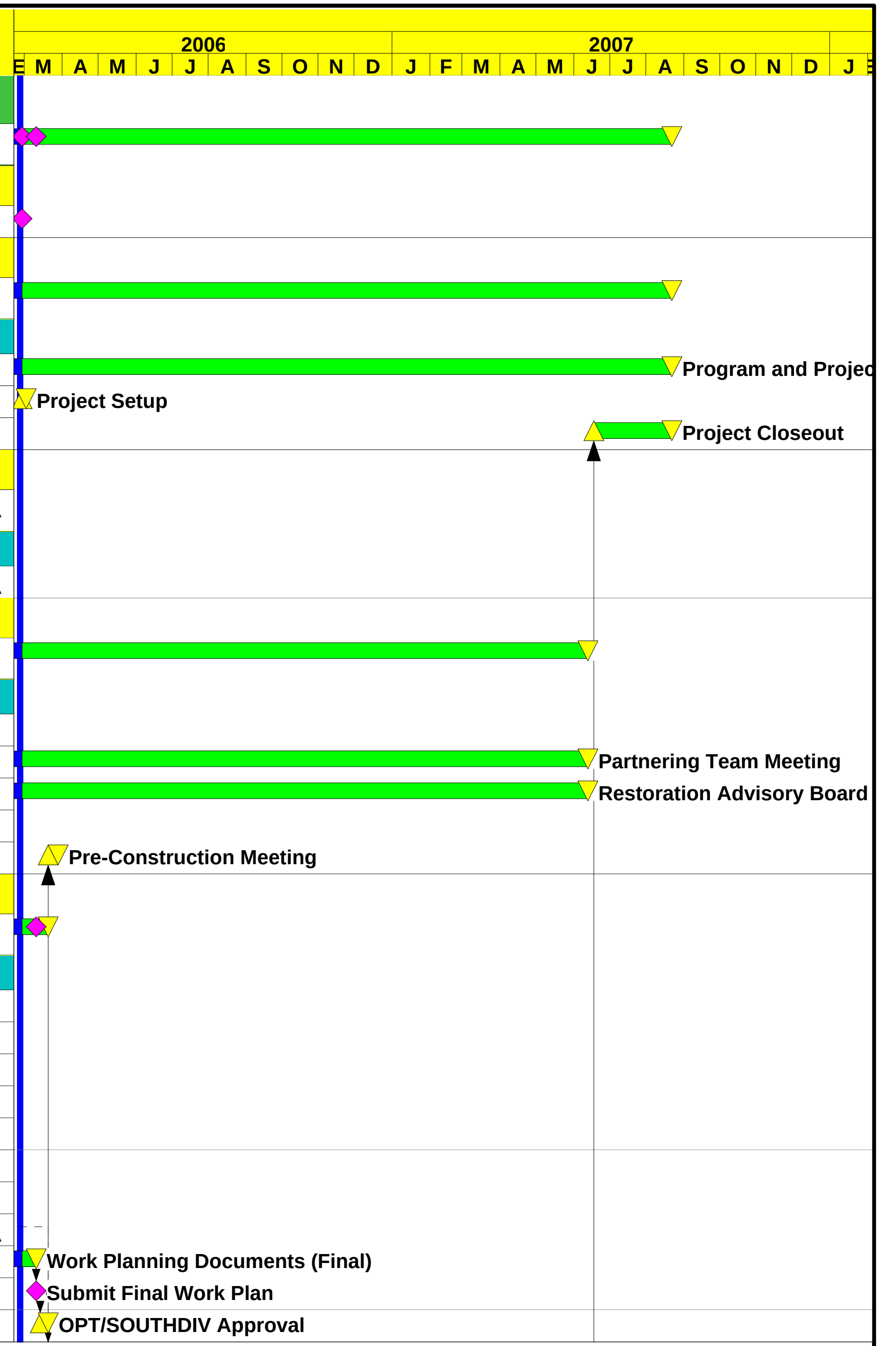
FDEP letter dated May 20, 2005 from Mr. Rick Ruscito, P.E. and Rebecca Lockenbach of the Bureau of Petroleum Storage Systems, FDEP, to Mr. Gary Birk of EOS Remediation, Inc.

Appendix A

CPM Project Schedule

Remedial Action at SA 17

Activity ID	WBS	Activity Description	Orig Dur	Rem Dur	% Comp	Early Start	Early Finish
Total			861	378	49	01APR04A	21AUG07
+ PROJECT AUTHORIZATION							
			483	0	0	01APR04A	24FEB06
PROJECT MANAGEMENT							
Subtotal			861	378	48	01APR04A	21AUG07
Project Management							
AI 0601	06.01	Program and Project Management	776	378	6	01APR04A	21AUG07
AI1200	1.2	Project Setup	3	3	0	27FEB06	01MAR06
AI1500	1.5	Project Closeout	45	45	0	19JUN07	21AUG07
BONDING							
Subtotal	08.01		1	0	100	28MAY04A	28MAY04A
Bonds, Permits, License & Fees							
AI 0801	08.01	Bonds	1	0	100	28MAY04A	28MAY04A
MEETINGS							
Subtotal			610	330	49	20JAN05A	13JUN07
Meetings							
AI 0501	05.01	Post Award Kickoff Meeting	325	0	100	20JAN05A	20JAN05A
AI 0504	05.04	Partnering Team Meeting	491	330	33	02MAY05A	13JUN07
AI 0505	05.05	Restoration Advisory Board Meetings	491	330	33	02MAY05A	13JUN07
AI 0502	05.02	Work Plan Design Review Meeting	2	0	100	28JUL05A	03JAN06A
AI 0503	05.03	Pre-Construction Meeting	5	5	0	21MAR06	27MAR06
PLANNING							
Subtotal			307	16	92	05JAN05A	20MAR06
Work Planning Documents							
AI 0101	01.01	Main Work Plan (DRAFT)	25	0	100	05JAN05A	07OCT05A
AI 0102	01.02	Health and Safety Plan	25	0	100	05JAN05A	07OCT05A
AI 0103	01.03	S&A Plan/Quality Assurance Plan	25	0	100	05JAN05A	07OCT05A
AI 0104	01.04	Waste Management Plan	25	0	100	05JAN05A	07OCT05A
AI 0105	01.05	Stormwater Pollution Plan	25	0	100	05JAN05A	07OCT05A
AI 0106	01.06	Quality Control Plan	25	0	100	05JAN05A	07OCT05A
AI 0107	01.07	Schedule	25	0	100	05JAN05A	07OCT05A
AI 0109		OPT/SOUTHDIV Review	10	0	100	10OCT05A	11NOV05A
AI 0110		Work Planning Documents (Final)	20	10	0	14NOV05A	10MAR06
AI 0111		Submit Final Work Plan	0	0	0		10MAR06
AI 0112		OPT/SOUTHDIV Approval	6	6	0	13MAR06	20MAR06



Start Date	17MAR04
Finish Date	21AUG07
Data Date	25FEB06
Run Date	02MAR06 11:30

Early Bar
Progress Bar
Critical Activity

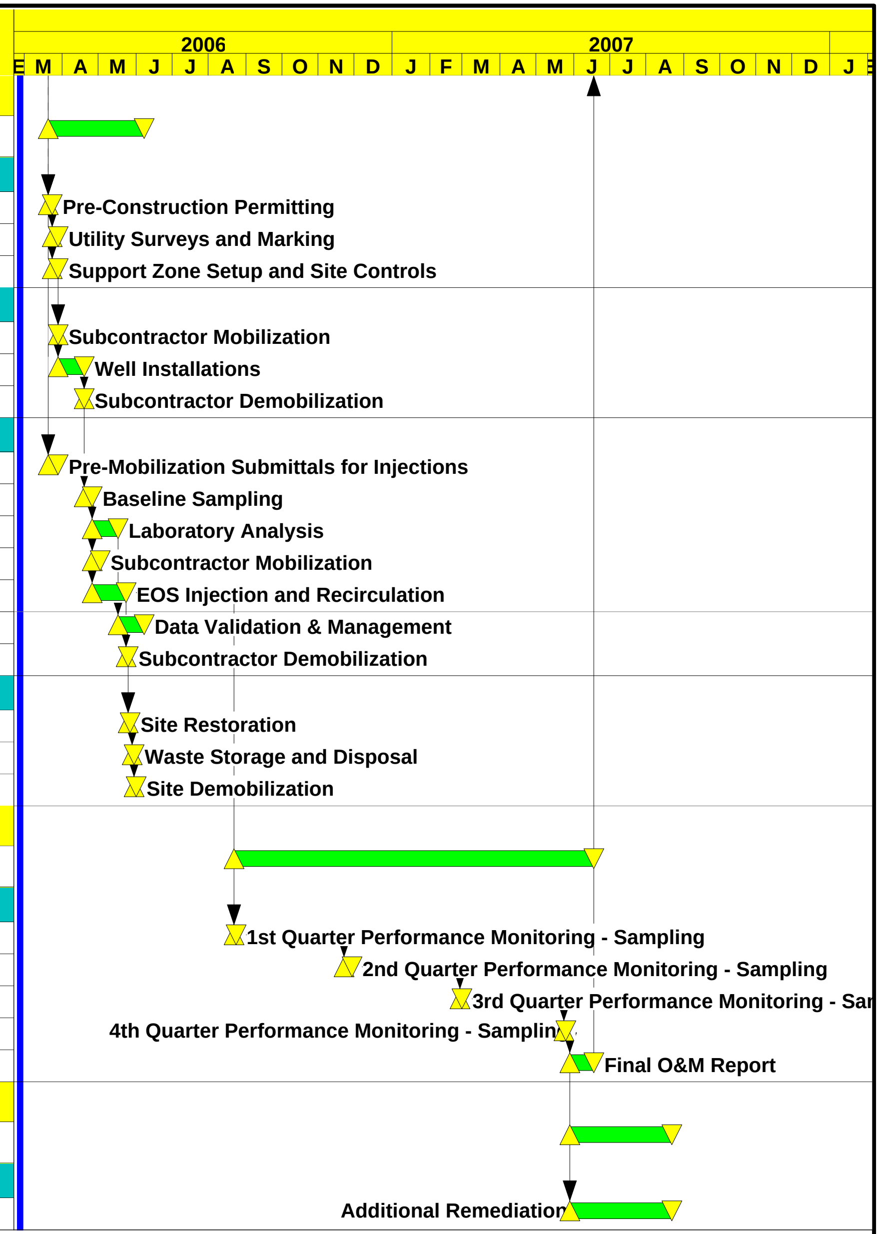
JVII - TO06

Sheet 1 of 2

Remedial Action at SA 17
Project Schedule

AGVIQ ENVIRONMENTAL SERVICES CH2M HILL JOINT VENTURE II

Activity ID	WBS	Activity Description	Orig Dur	Rem Dur	% Comp	Early Start	Early Finish
FIELD CONSTRUCTION							
Subtotal			56	56	0	21MAR06	07JUN06
MOBILIZATION & PREPARATORY WORK							
AI3100	3.1	Pre-Construction Permitting	3	3	0	21MAR06	23MAR06
AI3200	3.2	Utility Surveys and Marking	2	2	0	24MAR06	27MAR06
AI3300	3.3	Support Zone Setup and Site Controls	2	2	0	24MAR06	27MAR06
WELL INSTALLATIONS							
AI4100	4.1	Subcontractor Mobilization	1	1	0	28MAR06	28MAR06
AI4200	4.2	Well Installations	15	15	0	29MAR06	18APR06
AI4300	4.3	Subcontractor Demobilization	1	1	0	19APR06	19APR06
GROUNDWATER TREATMENT							
AI5100	5.1	Pre-Mobilization Submittals for Injections	5	5	0	21MAR06	27MAR06
AI5200	5.2	Baseline Sampling	5	5	0	19APR06	25APR06
AI5300	5.3	Laboratory Analysis	15	15	0	26APR06	16MAY06
AI5500	5.5	Subcontractor Mobilization	5	5	0	26APR06	02MAY06
AI5600	5.6	EOS Injection and Recirculation	20	20	0	26APR06	23MAY06
AI5400	5.4	Data Validation & Management	15	15	0	17MAY06	07JUN06
AI5700	5.7	Subcontractor Demobilization	2	2	0	24MAY06	25MAY06
SITE RESTORATION AND DEMOBILIZATION							
AI6100	6.1	Site Restoration	1	1	0	26MAY06	26MAY06
AI6200	6.2	Waste Storage and Disposal	1	1	0	30MAY06	30MAY06
AI6300	6.3	Site Demobilization	1	1	0	31MAY06	31MAY06
PERFORMANCE MONITORING							
Subtotal			209	209	0	22AUG06	18JUN07
ONE YEAR PERFORMANCE MONITORING							
AI7100	7.1	1st Quarter Performance Monitoring - Sampling	2	2	0	22AUG06	23AUG06
AI7200		2nd Quarter Performance Monitoring - Sampling	2	2	0	22NOV06	27NOV06
AI7300		3rd Quarter Performance Monitoring - Sampling	2	2	0	26FEB07	27FEB07
AI7400		4th Quarter Performance Monitoring - Sampling	2	2	0	24MAY07	25MAY07
AI7500		Final O&M Report	15	15	0	29MAY07	18JUN07
ADDITIONAL REMEDIATION (PENDING)							
Subtotal	8.1		60	60	0	29MAY07	21AUG07
ADDITIONAL REMEDIATION							
AI8100	8.1	Additional Remediation	60	60	0	29MAY07	21AUG07



Appendix B

Submittal Register

Submittal Register

Contract Number: N62467-03-D-0260			CTO No.: 0006		CTO Title: Injection, Extraction and Recirculation of EOS®, Study Area 17						Location: NTC Orlando, Orlando, Florida				Contractor: Agviq-CH2M HILL JVII		
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
Item Number	Work Plan Section No.	Item Description	Para. Number	Approving Authority	Other Reviewers	Submittal Number	Scheduled Submission Date	JVII Review Date	JVII Disposition	JVII Transmit Date	QC Admin Received Date	QC Disposition	QC Admin Transmit Date	Contracting Officer Received	Contracting Officer Disposition	Contracting Officer Return	Remarks
		General Paragraphs															
		SD-09, Reports	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
1	1.0	A Work Plan		ROICC													
2	1.0	B Narrative		ROICC													
3	7.0	C Environmental Protection Plan		ROICC													
	6.0	D Waste Management Plan															
5	Appendix E	E Health and Safety Plan and AHAs		ROICC													
6	9.0	E QA/QC Plan		ROICC													
7	5.0	F Sampling and Analysis Plan		ROICC													
8	4.0	G Decontamination Procedures	4.5	ROICC													
		SD-18, Records	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
10	3.0	A Process and Instrumentation Diagram	3.1.3	ROICC													
11	4.0	B Environmental Conditions Report	1.3.1.2	ROICC													
12	4.0	C Laboratory Test Results Summary Report	1.3.1.3	ROICC			Monthly										
13	9.0	D Daily Production Report	1.3.1.4	ROICC			Daily										
14	9.0	E Daily QC Report	1.3.1.5	ROICC			Daily										
15	9.0	F Rework Items List	1.3.1.6	ROICC			Monthly										
16	9.0	G Permits	1.3.1.7	ROICC			As Required										
17	9.0	H Construction Documentation Report	1.3.1.8	ROICC													
17	9.0	H Surveyor's Certification	1.3.1.8	ROICC													
		Remediation System Performance															
		SD-04, Drawings	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
36	4.0	A Treatment System Layout (P&ID)	1.2.2.b	JVII													
37	4.0	B Site Layout	1.2.2.d	JVII													
38	4.0	C Final Process Flow Diagram	1.2.2.e	JVII													
40	4.0	D Well Construction Records	3.4	JVII													
41	4.0	E O&M Reports	3.14	ROICC													
42	Appendix C	F Leak Tests Report	3.12.1	JVII													
	Appendix C	G EOS® and Groundwater Total Injection Volume Inventory															
	4.0	H Site Photos of Field Implementation of Remediation															
		SD-18, Records	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
44	4.0	A Well Driller Certification	3.4	JVII													
45	4.0	B Permits	1.2.4.b	JVII													
46	4.0	C MSDS Sheets	1.2.4.c	JVII													

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
Item Number	Work Plan Section No.	Item Description	Para. Number	Approving Authority	Other Reviewers	Submittal Number	Scheduled Submission Date	JVII Review Date	JVII Disposition	JVII Transmit Date	QC Admin Received Date	QC Disposition	QC Admin Transmit Date	Contracting Officer Received	Contracting Officer Disposition	Contracting Officer Return	Remarks
		Sampling Requirements															
		SD-08, Statements	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
53	5.0	A Sample Log	1.1.1.1	ROICC													
		SD-12, Field Test Reports	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
54	5.0	A Disposal Sample Analytical Results	1.1.2.1	ROICC													
55	5.0	B Screening Sample Results	1.1.2.2	ROICC													
56	5.0	C O&M Sample Analytical Results	1.1.2.3	ROICC													
57	5.0	D Electronic Copy of All Analytical Results	--	ROICC													
		SD-13, Certification	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
58	5.0	A Laboratory Certification	1.4.2	ROICC													
		Transportation and Disposal of Contaminated Material															
		SD-08, Statements	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
62	6.0	A Treatment Facility Permit	1.1.1.1	ROICC													
		SD-18, Records	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
73	6.0	A Shipment Manifests	1.1.2.1	ROICC													
64	6.0	B Delivery Certificates	1.1.2.2	ROICC													
67	6.0	C Treatment and Disposal Certificate	1.1.2.5	ROICC													
		Electrical System															
		SD-12, Field Test Reports	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
88	4.0	A GFCI Receptacle Test	3.2.3	JVII													
89	4.0	B Grounding System Test for Generator and Fuel Storage Tank	3.2.4	JVII													

Appendix C

Testing Plan and Log

Testing Plan and Log

Contract Number: N62467-03-D-0260	CTO No.: 0001	CTO Title: Injection and Recirculation of EOS®, SA 17	Location: NTC Orlando, Jacksonville, Florida	Contractor: Agviq-CH2M HILL JVII

A	B	C	D	E	F	G	H	I	J	K
Spec Section and Paragraph	**Test Required**	**Proposed Lab**	**Sampled By**	**Tested By**	**Test Location**	**Frequency**	**Date Test Made**	**Test Results**	**Date Results Forwarded**	**Remarks**
Section 5.0, SAP	Waste Characterization	TBD								Frequency and Analyses Specified in SAP
Section 5.0	Monitoring Well Sampling	TBD								Frequency and Analyses Specified in SAP
Section 5.0	Groundwater Level Measurements	Field								Frequency Specified in SAP
Appendix E, HASP	GFCI Receptacle Test	Field								Per HASP
Appendix E, HASP	Grounding System Test	Field								Per HASP
Section 9.0, QC Plan	Grounding System Test	Field								Per HASP

Appendix D

Project QC Manager Documentation

Eric L. Burrell

Education

B.S., Chemical Engineering, University of Alabama, 1992

Relevant Experience

Mr. Eric Burrell has a background in field engineering industrial and chemical processings, and construction. Mr. Burrell joined CH2M HILL Constructor's Inc. (CCI) in 1999. Mr. Burrell has acquired extensive field QA/QC experience from his previous work experience at three superfund sites. While working at those superfund sites, Mr. Burrell served as the Site QC officer and manager and was responsible for implementing the project Quality Control program in accordance with the Quality Assurance Plan. In addition to the QA/QC duties, Mr. Burrell was also involved in other aspects of those remediation projects, and was responsible for planning and implementing various field activities, such as managing wastewater treatment plant, installation of groundwater collection systems, inspecting installations pre-fabricated buildings, overseeing electrical/mechanical, inspecting layout and installation of various concrete installations, and coordinating the transportation and disposal of contaminated wastes at project sites.

Mr. Burrell's current position is QC Administrator for the Response Action Contract with the Navy Southern Division. In this position, Mr. Burrell facilitates implementation of the program-wide quality system for all Navy RAC contract task orders. Responsibilities include: review of the monthly status report to the Navy, monitoring and enforcement of the program/contract policies and procedures at the task order level, writing the quality control plan (entails submittal, testing, inspection and various meetings requirements) for project tasks, review and approval of subcontractor work plans, assist with trouble-shooting construction QC issues, review of project completion reports, and review of construction laboratory data.

Mr. Burrell has participated in the following projects:

CH2M HILL CONSTRUCTORS, INC.,. GCL TIE & Treating Superfund Site, Sidney, NY. Site Contractor Quality Control System Manager. Managed the site quality control system. Coordinated soil & water sampling activities and evaluated the data quality of the onsite and offsite laboratories. The scope of the multi-million dollar project included demolition, excavation, water treatment and on-site treatment of creosote-contaminated soils through low-temperature thermal desorption, and final site restoration. ***(Jun 1999 – May 2000)***

IT Group, Pittsburgh, PA., Ciba Specialty Chemicals Superfund Site, McIntosh, AL. Site QA/QC Manager. Ensured that regulatory requirements governing transportable incinerator were met and that compliance with design plans and specifications was maintained during site remedial activities. Clean up of 135,000 tons of chlorinated pesticide contaminated waste. ***(Sept 1997 – May 1999)***

- Prepared standard operating procedures for Quality Assurance Plan, conducted sampler training, directed all sampling and performed various inspections.
- Conducted plant commissioning and performed construction inspections during setup.
- Compiled, reviewed and processed data to generate daily contractor quality control reports, a synopsis of activities of thermal operations, field/civil crews, subcontractors, inspections, testing and laboratory analytical reports.

- As QC Engineer verified conformance with performance standards each of the following: treated product, thermal operations operating ranges and required calibrations, excavation/backfilling operations, sampling, HDPE liner installation. As-built drawings, revisions to project plans, definable features of work, water treatment plant operations, etc.
- Interacted with client daily to verify compliance and quality of workmanship.
- Teamed with surveying subcontractor to plan and direct detailed, strategic and accurate excavations utilizing laser-robotic surveying equipment.
- Provided technical support to wastewater treatment plant operations.

Sangamo Weston Superfund Site, Pickens, SC. Site QA/QC Officer. Project leader whom remedial activities were channeled through to ensure that schedule, compliance with contract specifications, and accounting proceedings were met. Clean up of 60,000 tons of PCB contaminated waste. ***(Sept 1995 – Sept 1999)***

- Elaborated on Quality Assurance Plan by coordinating sampling activities, verifying analytical, and performing various quality checks pertaining to field/thermal operations.
- Managed a wastewater treatment plant that was regulated by an NPDES permit. Plant set up to process groundwater, but was modified to treat heavily contaminated waters by using polymers and an array filters. Supervised three personnel.
- Transportation and disposal coordinator responsible for sampling, profiling, classifying, and manifesting all off-site waters. System of t racking saved of $50K in disposal costs.
- Inspected the installation of a groundwater collection system.
- Directed sampling of unknown drums and other solid wastes.
- Spent first 3 weeks with company as Recovery Technician. Assisted with construction of the wastewater treatment plant, haul roads, building foundations, and site set up.

Mobile Asphalt Company, Mobile, AL. Operator Trainee/Traffic Controller. Constructed paved interstate, state and county highways within 100-mile radius of city. Set up traffic control schemes that directed traffic flow and protected workers. ***(May 1995 - Sept 1995)***

Dowell Schlumberger, Midland, TX. Field Engineer. Supervised cementing and well acidizing services. Operations involved on–the-fly mixing and pumping of various types of fluids using many types of pumps at operating pressures reaching 10,000 psi. Maintained equipment and instruments, daily configured rigging and site set up. ***(Feb 1993 – Mar 1995)***

- Completed 13-week Field Engineer Training course, which consisted of design and evaluation of cementing and acidizing services, mechanical aptitude (rebuild/repair valves, hydraulic pumps and motors, throttles, etc.) operations (logistics, operation of pumps and mixers).
- Supervised crews of 2 to 8 persons from a pool of 50.

Boise Cascade Corporation, Jackson, AL. Cooperative Education Participant. Technical assistant to process/project engineers, supported operations with collection of process data used to produce production reports, maintained daily and weekly chemical inventory. ***(May 1988 – Aug 1990)***

- Soda Loss Project: determined causes and losses of sodium based products for Pulp Mill area.
- Dioxin Project: coordinated the collection of process samples and waste samples under normal versus controlled operation in effort to pinpoint and quantify dioxins.
- Generated a series of isometric drawings that were used to optimize production of evaporators and boilers.

Training

40-Hour HAZWOPER, 29 CFR 1910.120(e)
OSHA 8-Hour Refresher Training, 29 CFR 1910.120(e)(8)
Asbestos Awareness/AHERA Training 29 CFR 1926.1101 (k)9(vi)
Construction Quality Management for Contractors, USACE 1999
Excavation Competent Person, 29 CFR Subpart P
Site Safety Coordinator Course, 29 CFR 1910.120
10-Hour Construction Awareness Course
First-Aid/CPR Refresher

Appendix E

Site-Specific Health and Safety Plan

Health and Safety Plan
NTC Orlando Study Area 17

Navy Training Center, McCoy Annex
Orlando, Florida

Contract No. N62467-03-D-0260
Contract Task Order No. 006

Revision 00

Submitted to:

U.S. Naval Facilities
Engineering Command
Southern Division

Prepared by:

AGVIQ
AGVIQ ENVIRONMENTAL SERVICES
CH2M HILL
JOINT VENTURE

115 Perimeter Center Place, N.E.
Suite 700
Atlanta, GA 30346

July 2005

Contents

Attachments

1 Employee Signoff Form – Field Safety Instructions
2 Project-Specific Chemical Product Hazard Communication Form
3 Chemical-Specific Training Form
4 Emergency Contacts
5 Project Activity Self-Assessment Checklists/Permits/Forms
6 Behavior Based Loss Prevention System Forms
7 Applicable Material Safety Data Sheets
8 Subcontractor H&S Plans/Procedures

Acronyms

°F	degrees Fahrenheit
AHA	Activity Hazard Analysis
ALARA	as low as reasonably achievable
APR	air-purifying respirator
ATL	Atlanta
BBLPS	Behavior Based Loss Prevention System
CCI	CH2M HILL Constructors, Inc.
CNS	central nervous system
CPR	cardiopulmonary resuscitation
CTO	Contract Task Order
dBA	decibel A-rated
DOT	Department of Transportation
FA	first aid
FID	flame ionization detector
GFCI	ground fault circuit interrupter
HAZCOM	hazard communication
HR	heart rate
HSM	Health and Safety Manager
HSP	Health and Safety Plan
IDLH	immediately dangerous to life and health
IDW	investigation-derived waste
IRF	Incident Report Form
JVII	Joint Venture (CH2M Hill/AGVIQ)
lb	pound
LEL	lower explosive limit
LPO	Loss Prevention Observations
mg/m^3	milligrams per cubic meter
MSDS	Material Safety Data Sheet
mW/cm^2	milliwatt per square centimeter
NAVFAC EFD SOUTH	U.S. Navy Facilities Engineering Command, Southern Division
NDG	nuclear density gauge
NLI	Near Loss Investigation
NS	Naval Station
NSC	National Safety Council
NTR	Navy Technical Representative
OSHA	Occupational Safety and Health Administration
PAHs	polynuclear aromatic hydrocarbons
PAPR	powered air-purifying respirator
PDF	personal flotation device
PID	photoionization detector
PPE	personal protective equipment
ppm	parts per million
PTSP	Pre-Task Safety Plan

RMSF	Rocky Mountain Spotted Fever
SAR	supplied-air respirator
SCBA	self-contained breathing apparatus
SHSS	Site Health and Safety Specialist
SOP	standard of practice
STEL	short-term exposure limit
SZ	support zone
T&D	Transportation and disposal
TBD	to be determined
TMCC	truck-mounted crash cushion
TRPHs	total recoverable petroleum hydrocarbons
TSDF	treatment, storage, and disposal facility
UST	underground storage tank
VOCs	volatile organic compounds

This Health and Safety Plan (HSP) will be kept on the site during field activities and will be reviewed as necessary. The plan will be amended or revised as project activities or conditions change or when supplemental information becomes available. The plan adopts, by reference, the Standards of Practice (SOPs) in the CH2M HILL *Corporate Health and Safety Program, Program and Training Manual*, as appropriate. In addition, this plan adopts procedures in the project Work Plan. The Site Health and Safety Specialist (SHSS) is to be familiar with these SOPs and the contents of this plan. JVII Constructors Inc.'s (CH2M HILL) personnel and subcontractors must sign Attachment 1.

1.0 Project Information and Description

CONTRACT TASK ORDER (CTO) No: 006

CLIENT: Southern Division, U.S. Navy Facilities Engineering Command (NAVFAC EFD SOUTH)

PROJECT/SITE NAME: SA-17

SITE ADDRESS: Avenue C and Binnacle Way, NTC Orlando, McCoy Annex

JVII PROJECT MANAGER: Sam Naik

JVII OFFICE: ATL

DATE HEALTH AND SAFETY PLAN PREPARED: July, 2005

DATE(S) OF SITE WORK: July-September, 2005

SITE BACKGROUNG AND SETTING: SA-17 occupies approximately 25 acres in the central part of the McCoy Annex. The site includes Buildings 7178, 7190, 7189, and the adjacent area that formerly served as the Defense Property Disposal Office (DPDO) complex for the McCoy Annex. The southwestern corner of the site is undeveloped. A shallow canal that drains to the east extends along the entire southern boundary of the site. Figure 1-1 depicts the SA-17 site with the drainage ditch.

SA-17 is a former motor pool area and includes a vehicle wash rack and historic drum storage of waste fuel, oil, and ethylene glycol. The target treatment area has a relatively flat topography at approximately 90 feet above sea level with the shallow canal boarding the treatment area on the south/southwest.

DESCRIPTION OF SPECIFIC TASKS TO BE PERFORMED: The activities associated with the scope of work are as follows:

- Mobilization and site preparation
- Installation of Piezometers
- Aquifer Testing
- Pilot Scale Groundwater Extraction
- Enhanced Organic Substrate (EOS) Injection
- Decontamination
- Site restoration
- Demobilization
- Post-treatment groundwater sampling and analyses

2.0 Tasks to be Performed Under this Plan

Refer to project documents (i.e., Work Plan) for detailed task information. A health and safety risk analysis (Table 2-1) has been performed for each task and is incorporated in this plan through task-specific hazard controls and requirements for monitoring and protection. Tasks other than those listed below require an approved amendment or revision to this plan before tasks begin.

2.1 Hazwoper-Regulated Tasks

- Mobilization and Site Preparation
- Installation of Piezometers
- Aquifer Testing
- Pilot scale groundwater extraction
- EOS Injection
- Decontamination
- Demobilization
- Post-excavation Groundwater Sampling and Analyses

2.2 Non-Hazwoper-Regulated Tasks

Under specific circumstances, the training and medical monitoring requirements of federal or state Hazwoper regulations are not applicable. It must be demonstrated that the tasks can be performed without the possibility of exposure in order to use non-Hazwoper-trained personnel. **Prior approval from the Health and Safety Manager (HSM) is required before these tasks are conducted on regulated hazardous waste sites.**

Tasks	Controls
• Site Restoration • Preparation and Submittal of a Source Removal Report	• Brief on hazards, limits of access, and emergency procedures • Post contaminant areas as appropriate • Sample and monitor as appropriate

TABLE 2.1
Hazard Analysis
(Refer to Section 3 for hazard controls)

Potential Hazards	Project Activities									
	Mobilization and Site Setup	**Installation of Piezometer(s)**	**Aquifer Testing**	**Pilot Scale Groundwater Extraction**	**EOS Injection**	**Decontamination**	**Site Restoration**	**Demobilization**	**Post-Treatment Groundwater Monitoring**	
Manual Lifting (HS-29)	X	X	X	X	X	X	X	X	X	
Fire Prevention (HS-22)	X	X	X	X	X	X	X	X		
Electrical Safety (HS-23)		X								
Lockout /Tagout (HS-33)										
Ladders & Stairs(HS-25)										
Compressed Gas Cylinders (HS-63)					X					
Buried Utilities		X								
Excavations (HS-32)										
Fall Protection (HS-31)										
Heavy Equipment (HS-27)										
Confined Space Entry (HS-17)										
Concrete & Masonry Work (HS-43)										
Cranes and Hoisting (HS-44)										
Demolition (HS-45)										
Scaffolding(HS-73)										
Steel erection (HS-62)										
Welding and cutting (HS-22)										
Aerial Lifts (HS-41)										
Hand & Power Tools (HS-50)	X	X	X	X	X	X	X	X	X	
Forklifts (HS-48)										
Drilling (HS_35)		X								
Noise (HS-39)	X	X		X	X	X				
Pressurized Lines/Equipment					X		X			
Pressure Washing/Equip Decon							X			
Vacuum Truck/Pumping Operations				X						
Suspended Loads										
Vehicle Traffic	X		X		X					
Haul Truck Operations										
Visible Lighting	X	X	X	X	X	X	X	X	X	
Mechanical Guarding Hazards				X	X					
Asbestos Hazard										
Lead Hazard										
Chemical Hazard-Dermal/Inhalation		X	X	X	X	X			X	
Dust Hazard (Silica/Metals)										
Fire/Explosion Hazards										

3.0 Hazard Controls

This section provides safe work practices and control measures used to reduce or eliminate potential hazards. These practices and controls are to be implemented by the party in control of either the site or the particular hazard. JVII employees and subcontractors must remain aware of the hazards affecting them regardless of who is responsible for controlling the hazards. CH2M HILL employees and subcontractors who do not understand any of these provisions should contact the SHSS for clarification.

The health and safety hazards posed by field activities have been identified for each project activity and is provided in the Hazard Analysis Table (Table 2-1) in this section. Hazard control measures for project-specific and general H&S hazards are provided in 3.1 and 3.2 of this section.

Activity Hazard Analysis will be prepared before beginning each project activity posing H&S hazards to project personnel using the AHA form provided in the HSP Attachments as a guide. The AHA shall identify the work tasks required to perform each activity, along with potential H&S hazards and recommended control measures for each work task. In addition, a listing of the equipment to be used to perform the activity, inspection requirements and training requirements for the safe operation of the equipment listed must be identified. **AHAs shall be submitted to the Navy Technical Representative (NTR) for review at least 15 days prior to the start of each project activity phase**.

In addition to the controls specified in this section, Project-Activity Self-Assessment Checklists are contained in Attachment 5. These checklists are to be used to assess the adequacy of CH2M HILL and subcontractor site-specific safety requirements. The objective of the self-assessment process is to identify gaps in project safety performance, and prompt for corrective actions in addressing these gaps. Self-assessment checklists should be completed early in the project, when tasks or conditions change, or when otherwise specified by the HSM. The self-assessment checklists, including documented corrective actions, should be made part of the permanent project records.

Project-activity self-assessments checklist will be completed weekly by the SHSS during the course of the project, completing the applicable checklist depending on the work performed at the time on the project.

3.1 Project-Specific Hazards

3.1.1 Drilling Safety

- The drill rig is not to be operated in inclement weather.
- The driller is to verify that the rig is properly leveled and stabilized before raising the mast.
- Personnel should be cleared from the sides and rear of the rig before the mast is raised.

- The driller is not to drive the rig with the mast in the raised position.
- The driller must check for overhead power lines before raising the mast. A minimum distance of 15 feet between mast and overhead lines (<50 kV) is recommended. Increased separation may be required for lines greater than 50 kV.
- Personnel should stand clear before rig startup.
- The driller is to verify that the rig is in neutral when the operator is not at the controls.
- Become familiar with the hazards associated with the drilling method used (cable tool, air rotary, hollow-stem auger, etc.).
- Do not wear loose-fitting clothing, watches, etc., that could get caught in moving parts.
- Do not smoke or permit other spark-producing equipment around the drill rig.
- The drill rig must be equipped with a kill wire or switch, and personnel are to be informed of its location.
- Be aware and stand clear of heavy objects that are hoisted overhead.
- The driller is to verify that the rig is properly maintained in accordance with the drilling company's maintenance program.
- The driller is to verify that all machine guards are in place while the rig is in operation.
- The driller is responsible for housekeeping (maintaining a clean work area).
- The drill rig should be equipped with at least one fire extinguisher.

If the drill rig comes into contact with electrical wires and becomes electrically energized, do not touch any part of the rig or any person in contact with the rig, and stay as far away as possible. Notify emergency personnel immediately.

3.1.2 Procedures for Locating Buried Utilities

Local Utility Mark-Out Service

Name: Sunshine State One Call/ **Phone:** 1-800-432-4770

- A dig permit must be issued prior to any ground-disturbing activities.
- Where available, obtain utility diagrams for the facility.
- Review locations of sanitary and storm sewers, electrical conduits, water supply lines, natural gas lines, and fuel tanks and lines.
- Review proposed locations of intrusive work with facility personnel knowledgeable of locations of utilities. Check locations against information from utility mark-out service.
- Where necessary (e.g., uncertainty about utility locations), excavation or drilling of the upper depth interval should be performed manually.

- Monitor for signs of utilities during advancement of intrusive work (e.g., sudden change n advancement of auger or split spoon).
- When the client or other on-site party is responsible for determining the presence and locations of buried utilities, the SHSO should confirm that arrangement.

3.1.3 Enhanced Organic Substrate (EOS) Injection

(Reference CH2M HILL, SOP HS-22, *Welding and Cutting*)

- Review MSDS for all materials used with site personnel.
- Wear appropriate personal protective equipment for materials used and pressurized lines.
- Inspect all equipment, hoses, pressure lines and fittings daily and prior to pressurizing.
- Maintain site security to keep unauthorized personnel out of the operational area.

3.1.4 Working around Material Handling Equipment

- Never approach operating equipment from the rear. Always make positive contact with the operator, and confirm that the operator has stopped the motion of the equipment.
- Never approach the side of operating equipment; remain outside of the swing and turning radius.
- Maintain distance from pinch points of operating equipment.
- Because heavy equipment may not be equipped with properly functioning reverse signal alarms, never turn your back on any operating equipment.
- Never climb onto operating equipment or operate contractor/subcontractor equipment.
- Never ride contractor/subcontractor equipment unless it is designed to accommodate passengers; equipped with firmly attached passenger seat.
- Never work or walk under a suspended load.
- Never use equipment as a personnel lift; do not ride excavator buckets or crane hooks.
- Always stay alert and maintain a safe distance from operating equipment, especially equipment on cross slopes and unstable terrain.

3.1.5 Forklift Operations

Forklifts may be required for materials movement during project activities. Forklifts present the potential for damage to equipment, materials and personnel by impaling or striking personnel or materials with the forklift tines. Additionally, forklifts may tip if they are incorrectly loaded, driven at excessive speeds or operated with the forks too high.

The following rules apply whenever a forklift is used on the project:

- A rated lifting capacity must be posted in a location readily visible to the operator.

- A forklift truck must not be used to elevate employees unless a platform with guardrails, a back guard, and a kill switch is provided on the vehicle. When guardrails are not possible, fall arrest protection is required.
- The subcontractor operating the forklift must post and enforce a set of operating rules for forklift trucks.
- Only trained and authorized drivers will operate forklifts.
- Stunt driving and horseplay are prohibited.
- Employees must not ride on the forks.
- Employees must never be permitted under the forks (unless forks are blocked).
- The driver must inspect the forklift once a shift and document this inspection.
- The operator must look in the direction of travel and must not move the vehicle until all persons are clear of the vehicle.
- Forks must be carried as low as possible.
- The operator must lower the forks, shut off the engine, and set the brakes (or block the wheels) before leaving the forklift operator's position unless maintenance or safety inspections require the forklift to be running.
- Trucks must be blocked and have brakes set when forklifts are driven onto their beds.
- Extreme care must be taken when tilting elevated loads.
- Every forklift must have operable brakes capable of safely stopping it when fully loaded.
- Forklifts must have parking brakes and an operable horn.
- When the operator is exposed to possible falling objects, industrial trucks must be equipped with overhead protection (canopy).

3.1.6 Exposure to Public Vehicular Traffic

The following precautions must be taken when working around traffic, and in or near an area where traffic controls have been established by a contractor.

- Exercise caution when exiting traveled way or parking along street – avoid sudden stops, use flashers, etc.
- Park in a manner that will allow for safe exit from vehicle, and where practicable, park vehicle so that it can serve as a barrier.
- All staff working adjacent to traveled way or within work area must wear reflective/high-visibility safety vests.
- Eye protection should be worn to protect from flying debris.

- Remain aware of factors that influence traffic related hazards and required controls – sun glare, rain, wind, flash flooding, limited sight-distance, hills, curves, guardrails, width of shoulder (i.e., breakdown lane), etc.
- Always remain aware of an escape route—behind an established barrier, parked vehicle, guardrail, etc.
- Always pay attention to moving traffic—never assume drivers are looking out for you
- Work as far from traveled way as possible to avoid creating confusion for drivers.
- When workers must face away from traffic, a "buddy system" should be used, where one worker is looking towards traffic.
- When working on highway projects, obtain a copy of the contractor's traffic control plan.
- Work area should be protected by a physical barrier—such as a K-rail or Jersey barrier.
- Review traffic control devices to ensure that they are adequate to protect your work area. Traffic control devices should: 1) convey a clear meaning, 2) command respect of road users, and 3) give adequate time for proper traffic response. The adequacy of these devices are dependent on limited sight distance, proximity to ramps or intersections, restrictive width, duration of job, and traffic volume, speed, and proximity.
- Either a barrier or shadow vehicle should be positioned a considerable distance ahead of the work area. The vehicle should be equipped with a flashing arrow sign and truck-mounted crash cushion (TMCC). All vehicles within 40 feet of traffic should have an orange flashing hazard light atop the vehicle.
- Except on highways, flaggers should be used when 1) two-way traffic is reduced to using one common lane, 2) driver visibility is impaired or limited, 3) project vehicles enter or exit traffic in an unexpected manner, or 4) the use of a flagger enhances established traffic warning systems.
- Lookouts should be used when physical barriers are not available or practical. The lookout continually watches approaching traffic for signs of erratic driver behavior and warns workers. Vehicles should be parked at least 40 feet away from the work zone and traffic. Minimize the amount of time that you will have your back to oncoming traffic.

3.2 General Hazards

3.2.1 General Practices and Housekeeping

(Reference CH2M HILL- SOP HS-20, *General Practices*)

- Site work should be performed during daylight hours whenever possible. Work conducted during hours of darkness require enough illumination intensity to read a newspaper without difficulty.
- Good housekeeping must be maintained at all times in all project work areas.

- Common paths of travel should be established and kept free from the accumulation of materials.
- Keep access to aisles, exits, ladders, stairways, scaffolding, and emergency equipment free from obstructions.
- Provide slip-resistant surfaces, ropes, and/or other devices to be used.
- Specific areas should be designated for the proper storage of materials.
- Tools, equipment, materials, and supplies shall be stored in an orderly manner.
- As work progresses, scrap and unessential materials must be neatly stored or removed from the work area.
- Containers should be provided for collecting trash and other debris and shall be removed at regular intervals.
- All spills shall be quickly cleaned up. Oil and grease shall be cleaned from walking and working surfaces.

3.2.2 Hazard Communication

(Reference CH2M HILL-SOP HS-05, *Hazard Communication)*

The SHSS is to perform the following:

- Complete an inventory of chemicals brought on site by CH2M HILL using Attachment 2.
- Confirm that an inventory of chemicals brought on site by CH2M HILL subcontractors is available.
- Request or confirm locations of Material Safety Data Sheets (MSDSs) from the client, contractors, and subcontractors for chemicals to which CH2M HILL employees potentially are exposed.
- Before or as the chemicals arrive on site, obtain an MSDS for each hazardous chemical.
- Label chemical containers with the identity of the chemical and with hazard warnings, and store properly.
- Give employees required chemical-specific HAZCOM training using Attachment 3.
- Store all materials properly, giving consideration to compatibility, quantity limits, secondary containment, fire prevention, and environmental conditions.

3.2.3 Shipping and Transportation of Chemical Products

(Reference CH2M HILL's *Procedures for Shipping and Transporting Dangerous Goods)*

Chemicals brought to the site might be defined as hazardous materials by the U.S. Department of Transportation (DOT). All staff who ship the materials or transport them by road must receive CH2M HILL training in shipping dangerous goods. All hazardous materials that are shipped (e.g., via Federal Express) or are transported by road must be properly identified, labeled, packed, and documented by trained staff. Contact the HSM or the Equipment Coordinator for additional information.

3.2.4 Lifting

(Reference CH2M HILL-SOP HS-29, *Lifting*)

- Proper lifting techniques must be used when lifting any object.
- Plan storage and staging to minimize lifting or carrying distances.
- Split heavy loads into smaller loads.
- Use mechanical lifting aids whenever possible.
- Have someone assist with the lift -- especially for heavy or awkward loads.
- Make sure the path of travel is clear prior to the lift.

3.2.5 Fire Prevention

(Reference CH2M HILL- SOP HS-22, *Fire Prevention*)

- Fire extinguishers shall be provided so that the travel distance from any work area to the nearest extinguisher is less than 100 feet. When 5 gallons or more of a flammable or combustible liquid is being used, an extinguisher must be within 50 feet. Extinguishers must:
  - be maintained in a fully charged and operable condition,
  - be visually inspected each month, and
  - undergo a maintenance check each year.
- The area in front of extinguishers must be kept clear.
- Post "Exit" signs over exiting doors, and post "Fire Extinguisher" signs over extinguisher locations.
- Combustible materials stored outside should be at least 10 feet from any building.
- Solvent waste and oily rags must be kept in a fire resistant, covered container until removed from the site.
- Flammable/combustible liquids must be kept in approved containers, and must be stored in an approved storage cabinet.

3.2.6 Electrical

(Reference CH2M HILL-SOP HS-23, *Electrical*)

- Only qualified personnel are permitted to work on unprotected energized electrical systems.
- Only authorized personnel are permitted to enter high-voltage areas.
- Do not tamper with electrical wiring and equipment unless qualified to do so. All electrical wiring and equipment must be considered energized until lockout/tagout procedures are implemented.

- Inspect electrical equipment, power tools, and extension cords for damage prior to use. Do not use defective electrical equipment, remove from service.
- All temporary wiring, including extension cords and electrical power tools, must have ground fault circuit interrupters (GFCIs) installed.
- Extension cords must be:
    - equipped with third-wire grounding.
    - covered, elevated, or protected from damage when passing through work areas.
    - protected from pinching if routed through doorways.
    - not fastened with staples, hung from nails, or suspended with wire.
- Electrical power tools and equipment must be effectively grounded or double-insulated UL approved.
- Operate and maintain electric power tools and equipment according to manufacturers' instructions.
- Maintain safe clearance distances between overhead power lines and any electrical conducting material unless the power lines have been de-energized and grounded, or where insulating barriers have been installed to prevent physical contact. Maintain at least 10 feet from overhead power lines for voltages of 50 kV or less, and 10 feet plus ½ inch for every 1 kV over 50 kV.
- Temporary lights shall not be suspended by their electric cord unless designed for suspension. Lights shall be protected from accidental contact or breakage.
- Protect all electrical equipment, tools, switches, and outlets from environmental elements.

3.2.7 Stairways and Ladders

(Reference CH2M HILL-SOP HS-25, *Stairways and Ladders*)

- Stairway or ladder is generally required when a break in elevation of 19 inches or greater exists.
- Personnel should avoid using both hands to carry objects while on stairways; if unavoidable, use extra precautions.
- Personnel must not use pan and skeleton metal stairs until permanent or temporary treads and landings are provided the full width and depth of each step and landing.
- Ladders must be inspected by a competent person for visible defects prior to each day's use. Defective ladders must be tagged and removed from service.
- Ladders must be used only for the purpose for which they were designed and shall not be loaded beyond their rated capacity.
- Only one person at a time shall climb on or work from an individual ladder.
- User must face the ladder when climbing; keep belt buckle between side rails

- Ladders shall not be moved, shifted, or extended while in use.
- User must use both hands to climb; use rope to raise and lower equipment and materials
- Straight and extension ladders must be tied off to prevent displacement
- Ladders that may be displaced by work activities or traffic must be secured or barricaded
- Portable ladders must extend at least 3 feet above landing surface
- Straight and extension ladders must be positioned at such an angle that the ladder base to the wall is one-fourth of the working length of the ladder
- Stepladders are to be used in the fully opened and locked position
- Users are not to stand on the top two steps of a stepladder; nor are users to sit on top or straddle a stepladder
- Fixed ladders > 24 feet in height must be provided with fall protection devices.
- Fall protection should be considered when working from extension, straight, or fixed ladders greater than 6 feet from lower levels and both hands are needed to perform the work, or when reaching or working outside of the plane of ladder side rails.

3.2.8 Heat Stress

(Reference CH2M HILL- SOP HS-09, *Heat and Cold Stress*)

- Drink 16 ounces of water before beginning work. Disposable cups and water maintained at 50oF to 60oF should be available. Under severe conditions, drink one to two cups every 20 minutes, for a total of 1 to 2 gallons per day. Do not use alcohol in place of water or other nonalcoholic fluids. Decrease your intake of coffee and caffeinated soft drinks during working hours.
- Acclimate yourself by slowly increasing workloads (e.g., do not begin with extremely demanding activities).
- Use cooling devices, such as cooling vests, to aid natural body ventilation. These devices add weight, so their use should be balanced against efficiency.
- Use mobile showers or hose-down facilities to reduce body temperature and cool protective clothing.
- Conduct field activities in the early morning or evening and rotate shifts of workers, if possible.
- Avoid direct sun whenever possible, which can decrease physical efficiency and increase the probability of heat stress. Take regular breaks in a cool, shaded area. Use a wide-brim hat or an umbrella when working under direct sun for extended periods.
- Provide adequate shelter/shade to protect personnel against radiant heat (sun, flames, hot metal).

- Maintain good hygiene standards by frequently changing clothing and showering.
- Observe one another for signs of heat stress. Persons who experience signs of heat syncope, heat rash, or heat cramps should consult the SHSS to avoid progression of heat-related illness.

Symptoms and Treatment of Heat Stress					
	Heat Syncope	Heat Rash	Heat Cramps	Heat Exhaustion	Heat Stroke
Signs and Symptoms	Sluggishness or fainting while standing erect or immobile in heat.	Profuse tiny raised red blister-like vesicles on affected areas, along with prickling sensations during heat exposure.	Painful spasms in muscles used during work (arms, legs, or abdomen); onset during or after work hours.	Fatigue, nausea, headache, giddiness; skin clammy and moist; complexion pale, muddy, or flushed; may faint on standing; rapid thready pulse and low blood pressure; oral temperature normal or low	Red, hot, dry skin; dizziness; confusion; rapid breathing and pulse; high oral temperature.
Treatment	Remove to cooler area. Rest lying down. Increase fluid intake. Recovery usually is prompt and complete.	Use mild drying lotions and powders, and keep skin clean for drying skin and preventing infection.	Remove to cooler area. Rest lying down. Increase fluid intake.	Remove to cooler area. Rest lying down, with head in low position. Administer fluids by mouth. Seek medical attention.	Cool rapidly by soaking in cool–but not cold–water. Call ambulance, and get medical attention immediately!

3.2.8.1 Monitoring Heat Stress

These procedures should be considered when the ambient air temperature exceeds 70ºF, the relative humidity is high (>50 percent), or when workers exhibit symptoms of heat stress. The heart rate (HR) should be measured by the radial pulse for 30 seconds, as early as possible in the resting period. The HR at the beginning of the rest period should not exceed 100 beats/minute, or 20 beats/minute above resting pulse. If the HR is higher, the next work period should be shortened by 33 percent, while the length of the rest period stays the same. If the pulse rate still exceeds 100 beats/minute at the beginning of the next rest period, the work cycle should be further shortened by 33 percent. The procedure is continued until the rate is maintained below 100 beats/minute, or 20 beats/minute above resting pulse.

3.2.9 Cold Stress

(Reference CH2M HILL- SOP HS-09, *Heat and Cold Stress*)

- Be aware of the symptoms of cold-related disorders, and wear proper, layered clothing for the anticipated fieldwork. Appropriate rain gear is a must in cool weather.
- Consider monitoring the work conditions and adjusting the work schedule using guidelines developed by the U.S. Army (wind-chill index) and the National Safety Council (NSC).
- Wind-Chill Index is used to estimate the combined effect of wind and low air temperatures on exposed skin. The wind-chill index does not take into account the body part that is exposed, the level of activity, or the amount or type of clothing worn. For

those reasons, it should only be used as a guideline to warn workers when they are in a situation that can cause cold-related illnesses.

- NSC Guidelines for Work and Warm-Up Schedules can be used with the wind-chill index to estimate work and warm-up schedules for fieldwork. The guidelines are not absolute; workers should be monitored for symptoms of cold-related illnesses. If symptoms are not observed, the work duration can be increased.
- Persons who experience initial signs of immersion foot, frostbite, hypothermia should consult the SHSS to avoid progression of cold-related illness.
- Observe one another for initial signs of cold-related disorders.
- Obtain and review weather forecast – be aware of predicted weather systems along with sudden drops in temperature, increase in winds, and precipitation.

Symptoms and Treatment of Cold Stress			
	Immersion (Trench) Foot	**Frostbite**	**Hypothermia**
Signs and Symptoms	Feet discolored and painful; infection and swelling present.	Blanched, white, waxy skin, but tissue resilient; tissue cold and pale.	Shivering, apathy, sleepiness; rapid drop in body temperature; glassy stare; slow pulse; slow respiration.
Treatment	Seek medical treatment immediately.	Remove victim to a warm place. Re-warm area quickly in warm–but **not** hot–water. Have victim drink warm fluids, but **not** coffee or alcohol. Do not break blisters. Elevate the injured area, and get medical attention.	Remove victim to a warm place. Have victim drink warm fluids, but **not** coffee or alcohol. Get medical attention.

3.2.10 Compressed Gas Cylinders

- Valve caps must be in place when cylinders are transported, moved, or stored.
- Cylinder valves must be closed when cylinders are not being used and when cylinders are being moved.
- Cylinders must be secured in an upright position at all times.
- Cylinders must be shielded from welding and cutting operations and positioned to avoid being struck or knocked over; contacting electrical circuits; or exposed to extreme heat sources.
- Cylinders must be secured on a cradle, basket, or pallet when hoisted; they may not be hoisted by choker slings.

3.3 Biological Hazards and Controls

3.3.1 Snakes

Snakes typically are found in underbrush and tall grassy areas. If you encounter a snake, stay calm and look around; there may be other snakes. Turn around and walk away on the same path you used to approach the area. If a person is bitten by a snake, wash and immobilize the injured area, keeping it lower than the heart if possible. Seek medical attention immediately. **DO NOT** apply ice, cut the wound, or apply a tourniquet. Try to identify the type of snake: note color, size, patterns, and markings.

3.3.2 Poison Ivy and Poison Sumac

Poison ivy, poison oak, and poison sumac typically are found in brush or wooded areas. They are more commonly found in moist areas or along the edges of wooded areas. Become familiar with the identity of these plants. Wear protective clothing that covers exposed skin and clothes. Avoid contact with plants and the outside of protective clothing. If skin contacts a plant, wash the area with soap and water immediately. If the reaction is severe or worsens, seek medical attention.

3.3.3 Ticks

Ticks typically are in wooded areas, bushes, tall grass, and brush. Ticks are black, black and red, or brown and can be up to one-quarter inch in size. Wear tightly woven light-colored clothing with long sleeves and pant legs tucked into boots; spray **only outside** of clothing with permethrin or permanone and spray skin with only DEET; and check yourself frequently for ticks.

If bitten by a tick, grasp it at the point of attachment and carefully remove it. After removing the tick, wash your hands and disinfect and press the bite areas. Save the removed tick. Report the bite to human resources. Look for symptoms of Lyme disease or Rocky Mountain spotted fever (RMSF). Lyme: a rash might appear that looks like a bullseye with a small welt in the center. RMSF: a rash of red spots under the skin 3 to 10 days after the tick bite. In both cases, chills, fever, headache, fatigue, stiff neck, and bone pain may develop. If symptoms appear, seek medical attention.

3.3.4 Bees and Other Stinging Insects

Bee and other stinging insects may be encountered almost anywhere and may present a serious hazard, particularly to people who are allergic. Watch for and avoid nests. Keep exposed skin to a minimum. Carry a kit if you have had allergic reactions in the past, and inform the SHSS and/or buddy. If a stinger is present, remove it carefully with tweezers. Wash and disinfect the wound, cover it, and apply ice. Watch for allergic reaction; seek medical attention if a reaction develops.

3.3.5 Bloodborne Pathogens

(Reference CH2M HILL- SOP HS-36, *Bloodborne Pathogens*)

Exposure to bloodborne pathogens may occur when rendering first aid or CPR, or when coming into contact with landfill waste or waste streams containing potentially infectious material. Exposure controls and personal protective equipment (PPE) are required as specified in CH2M HILL SOP HS-36, *Bloodborne Pathogens*. Hepatitis B vaccination must be offered before the person participates in a task where exposure is a possibility.

3.3.6 Mosquito Bites

Due to the recent detection of the West Nile Virus in the Southeastern United States, it is recommended that **preventative measures** be taken to reduce the probability of being bitten by mosquitoes whenever possible. Mosquitoes are believed to be the primary source for exposure to the West Nile Virus as well as several other types of encephalitis. The following guidelines should be followed to reduce the risk of these concerns for working in areas where mosquitoes are prevalent:

- Stay indoors at dawn, dusk, and in the early evening.
- Wear long-sleeved shirts and long pants whenever you are outdoors.
- Spray clothing with repellents containing permethrin or DEET since mosquitoes may bite through thin clothing.
- Apply insect repellent sparingly to exposed skin. An effective repellent will contain 35 percent DEET (N,N-diethyl-meta-toluamide). DEET in high concentrations (greater than 35 percent) provides no additional protection.
- Repellents may irritate the eyes and mouth, so avoid applying repellent to the hands.
- Whenever you use an insecticide or insect repellent, be sure to read and follow the manufacturer's DIRECTIONS FOR USE, as printed on the product.

Note: Vitamin B and "ultrasonic" devices are NOT effective in preventing mosquito bites.

3.3.6.1 Symptoms of Exposure to the West Nile Virus

- Most infections are mild, and symptoms include fever, headache, and body aches, occasionally with skin rash and swollen lymph glands. More severe infection may be marked by headache, high fever, neck stiffness, stupor, disorientation, coma, tremors, convulsions, muscle weakness, paralysis, and, rarely, death.
- The West Nile Virus incubation period is from 3-15 days.
- If you have any questions or to report any suspicious symptoms, contact the project Health and Safety Manager.

3.4 Radiological Hazards and Controls

Refer to CH2M HILL's Corporate Health and Safety Program, Program and Training Manual, and Corporate Health and Safety Program, Radiation Protection Program Manual, for standards of practice in contaminated areas.

3.5 Contaminants of Concern

Contaminants of Concern are listed in Table 3-1.

TABLE 3-1
Contaminants of Concern

Contaminant	Location and Maximum[a] Concentration (ppm)	Exposure Limit[b]	IDLH[c]	Symptoms and Effects of Exposure	PIP[d] (eV)
TCE	SB: SS:	50 ppm	1000 Ca	Headache, vertigo, visual disturbance, eye and skin irritation, fatigue, giddiness, tremors, sleepiness, nausea, vomiting, dermatitis, cardiac arrhythmia, paresthesia, liver injury	9.45
TRPH	SB: 340 mg/kg	100 mg/m^3	1000	Eye, skin, and nose irritation; headache; dizziness; vomiting; dermatitis, burning sensation, in chest, weakness, chemical pneumonia	UK

Footnotes:
[a] Specify sample-designation and media: SB (Soil Boring).
[b] Appropriate value of PEL, REL, or TLV listed.
[c] IDLH = immediately dangerous to life and health (units are the same as specified “Exposure Limit” units for that contaminant); NL = No limit found in reference materials; CA = Potential occupational carcinogen.
[d] PIP = photoionization potential; NA = Not applicable; UK = Unknown.

3.6 Potential Routes of Exposure

Dermal: Contact with contaminated media. This route of exposure is minimized through proper use of PPE, as specified in Section 4.

Inhalation: Vapors and contaminated particulates. This route of exposure is minimized through proper respiratory protection and monitoring, as specified in Sections 4 and 5, respectively.

Other: Inadvertent ingestion of contaminated media. This route should not present a concern if good hygiene practices are followed (e.g., wash hands and face before drinking or smoking).

4.0 Project Organization and Personnel

4.1 CH2M HILL Employee Medical Surveillance and Training

(Reference CH2M HILL- SOPs HS-01, *Medical Surveillance*, and HS-02, *Health and Safety Training)*

The employees listed meet state and federal hazardous waste operations requirements for 40-hour initial training, 3-day on-the-job experience, and 8-hour annual refresher training. Employees designated "SHSS" have completed a 12-hour site safety coordinator course, and have documented requisite field experience. An SHSS with a level designation (D, C, B) equal to or greater than the level of protection being used must be present during all tasks performed in exclusion or decontamination zones. Employees designated "FA-CPR" are currently certified by the American Red Cross, or equivalent, in first aid and CPR. At least one FA-CPR designated employee must be present during all tasks performed in exclusion or decontamination zones. At least two FA-CPR trained employees must be available at each job site/operation. The employees listed below are currently active in a medical surveillance program that meets state and federal regulatory requirements for hazardous waste operations. Certain tasks (e.g., confined-space entry) and contaminants (e.g., lead) may require additional training and medical monitoring.

Pregnant employees are to be informed of and are to follow the procedures in CH2M HILL-SOP HS-04, *Reproduction Protection*, including obtaining a physician's statement of the employee's ability to perform hazardous activities before being assigned fieldwork.

Employee Name	Office	Responsibility	SHSS/FA-CPR
Steve Tsangaris	TPA		
Sam Naik	ATL	Project Manager	
William Elliot	GNV	Field Team Leader	
Rich Rathnow	ORO	Health & Safety Mgr	

4.2 Field Team Chain of Command and Communication Procedures

4.2.1 Client

Contact Name: _____
Phone: _____

4.2.2 JVII

Program Manager: Joe Collela/Scott Smith

Project Manager: Steve Tsangaris/TPA or Sam Naik/ATL
Health and Safety Manager: Rich Rathnow/ORO
Field Team Leader: William Elliot/GNV
Site Health and Safety Specialist: TBD
The CH2M HILL project manager (PM) is responsible for providing adequate resources (budget and staff) for project-specific implementation of the HS&E management process. The PM has overall management responsibility for the tasks listed below. The PM may explicitly delegate specific tasks to other staff, as described in sections that follow, but retains ultimate responsibility for completion of the following in accordance with this SOP:

- Include standard terms and conditions, and contract-specific HS&E roles and responsibilities in contract and subcontract agreements (including flow-down requirements to lower-tier subcontractors)
- Select safe and competent subcontractors by:
- obtaining, reviewing and accepting or rejecting subcontractor pre-qualification questionnaires
- ensuring that acceptable certificates of insurance, including JVII as named additional insured, are secured as a condition of subcontract award
- including HS&E submittals checklist in subcontract agreements, and ensuring that appropriate site-specific safety procedures, training and medical monitoring records are reviewed and accepted prior to the start of subcontractor's field operations
- Maintain copies of subcontracts and subcontractor certificates of insurance (including JVII as named additional insured), bond, contractors license, training and medical monitoring records, and site-specific safety procedures in the project file accessible to site personnel
- Provide oversight of subcontractor HS&E practices per the site-specific safety plan
- Manage the site and interfacing with 3rd parties in a manner consistent with our contract and subcontract agreements and the applicable standard of reasonable care
- Ensure that the overall, job-specific, HS&E goals are fully and continuously implemented

The CH2M HILL HSM is responsible for:

- Review and accept or reject subcontractor pre-qualification questionnaires that fall outside the performance range delegated to the Contracts Administrator (KA)
- Review and accept or reject subcontractor training records and site-specific safety procedures prior to start of subcontractor's field operations
- Support the SHSS's oversight of subcontractor (and lower-tier subcontractors) HS&E practices and interfaces with on-site 3rd parties per the site-specific safety plan
- The SHSS is responsible for verifying that the project is conducted in a safe manner including the following specific obligations:

- Verify this HSP remains current and amended when project activities or conditions change
- Verify CH2M HILL site personnel and subcontractor personnel read this HSP and sign Attachment 1 "Employee Signoff Form" prior to commencing field activities
- Verify CH2M HILL site personnel and subcontractor personnel have completed any required specialty training (e.g., fall protection, confined space entry) and medical surveillance as identified in Section 2
- Verify compliance with the requirements of this HSP and applicable subcontractor health and safety plan(s)
- Act as the project "Hazard Communication Coordinator" and perform the responsibilities outlined in Section 2.2.2
- Act as the project "Emergency Response Coordinator" and perform the responsibilities outlined in Section 4
- Post OSHA job-site poster; the poster is required at sites where project field offices, trailers, or equipment-storage boxes are established; posters can be obtained by calling 800/548-4776 or 800/999-9111
- Verify that safety meetings are conducted and documented in the project file initially and as needed throughout the course of the project (e.g., as tasks or hazards change)
- Verify that project H&S forms and permits, found in Attachment 5, are being used as outlined in Section 2
- Perform oversight and/or assessments of subcontractor HS&E practices per the site-specific safety plan and verify that project activity self-assessment checklists, found in Attachment 5, are being used as outlined in Section 2
- Verify that project files available to site personnel include copies of executed subcontracts and subcontractor certificates of insurance (including JVII as named additional insured), bond, contractors license, training and medical monitoring records, and site-specific safety procedures prior to start of subcontractor's field operations
- Manage the site and interfacing with 3rd parties in a manner consistent with our contract/subcontract agreements and the applicable standard of reasonable care
- Coordinate with the HS&E manager regarding JVII and subcontractor operational performance, and 3rd party interfaces
- Ensure that the overall, job-specific, HS&E goals are fully and continuously implemented
- The training required for the SHSS is as follows:
- SHSS 10 hour course
- OHSA 10 hour course for Construction

- First Aid and CPR
- Relevant Competent Person Courses (excavation, confined space, scaffold, fall protection, etc.)

The SHSS is responsible for contacting the Field Team Leader and Project Manager. In general, the Project Manager will contact the client. The Health and Safety Manager should be contacted as appropriate.

4.2.3 Subcontractors

(Reference CH2M HILL- SOP HS-55, *Subcontractor, Contractor, and Owner*)

Certain subcontractors (drilling, remedial and construction contractors) are required to be pre-qualified for safety by completing the Subcontractor Safety Performance Questionnaire. The subcontractors listed above are covered by this HSP. However, this plan does not address hazards associated with the tasks and equipment that the subcontractor has expertise in (e.g., drilling, excavation work, electrical). Subcontractors are responsible for the health and safety procedures specific to their work, and are required to submit these procedures to CH2M HILL for review before the start of field work by following the Subcontractor Safety Procedure Criteria specific to their work.

Subcontractors are also required to prepare Activity Hazard Analysis before beginning each activity posing H&S hazards to their personnel using the AHA form provided in Attachment 6 as a guide. The AHA shall identify the principle steps of the activity, potential H&S hazards for each step and recommended control measures for each identified hazard. In addition, a listing of the equipment to be used to perform the activity, inspection requirements and training requirements for the safe operation of the equipment listed must be identified.

Subcontractors must comply with the established health and safety plan(s). The JVII SHSS should verify that subcontractor employee training, medical clearance, and fit test records are current and must monitor and enforce compliance with the established plan(s). CH2M HILL oversight does not relieve subcontractors of their responsibility for effective implementation and compliance with the established plan(s).

JVII should continuously endeavor to observe subcontractors’ safety performance. This endeavor should be reasonable, and include observing for hazards or unsafe practices that are both readily observable and occur in common work areas. JVII is not responsible for exhaustive observation for hazards and unsafe practices. In addition to this level of observation, the SHSS is responsible for confirming JVII subcontractor performance against both the subcontractor’s safety plan and applicable self-assessment checklists. Self-assessment checklists contained in Attachment 5 are to be used by the SHSS to review subcontractor performance.

Health and safety related communications with JVII subcontractors should be conducted as follows:

- Brief subcontractors on the provisions of this plan, and require them to sign the Employee Signoff Form included in Attachment 1.

- Request subcontractor(s) to brief project team on the hazards and precautions related to their work.
- When apparent non-compliance/unsafe conditions or practices are observed, notify the subcontractor safety representative and require corrective action – the subcontractor is responsible for determining and implementing necessary controls and corrective actions.
- When repeat non-compliance/unsafe conditions are observed, notify the subcontractor safety representative and stop affected work until adequate corrective measures are implemented.
- When an apparent imminent danger exists, immediately remove all affected JVII employees and subcontractors, notify subcontractor safety representative, and stop affected work until adequate corrective measures are implemented. Notify the Project Manager and HSM as appropriate.
- Document all oral health and safety related communications in project field logbook, daily reports, or other records.

5.0 Personal Protective Equipment

(Reference CH2M HILL- SOP HS-07, *Personal Protective Equipment*, HS-08, *Respiratory Protection*)

PPE Specifications are listed in Table 5-1.

TABLE 5-1
PPE Specifications[a]

Task	Level	Body	Head	Respirator [b]
General site entry Oversight of remediation and construction Site Restoration	D	Work clothes; steel-toe, leather work boots; work glove.	Hardhat [c] Safety glasses Ear protection [d]	None required
Groundwater Sampling Piezometer Installation Aquifer Testing Post-Treatment Groundwater Sampling and Analyses	Modified D	Work clothes or cotton coveralls **Boots:** Steel-toe, chemical-resistant boots OR steel-toe, leather work boots with outer rubber boot covers **Gloves:** Inner surgical-style nitrile & outer chemical-resistant nitrile gloves.	Hardhat [c] Safety glasses Ear protection [d]	None required
EOS Injection	Modified D	**Coveralls:** Uncoated Tyvek® as necessary **Boots:** Steel-toe, chemical-resistant boots OR steel-toe, leather work boots with outer rubber boot covers **Gloves:** Inner surgical-style nitrile & outer chemical-resistant nitrile gloves.	Hardhat [c] Splash shield [c] Safety glasses Ear protection [d]	None required.
Tasks requiring upgrade	C	**Coveralls:** Polycoated Tyvek® **Boots:** Steel-toe, chemical-resistant boots OR steel-toe, leather work boots with outer rubber boot covers **Gloves:** Inner surgical-style nitrile & outer chemical-resistant nitrile gloves.	Hardhat [c] Splash shield [c] Ear protection [d] Spectacle inserts	APR, full face, MSA Ultratwin or equivalent; with GME-H cartridges or equivalent[e].
Tasks requiring upgrade	B	**Coveralls:** Polycoated Tyvek® **Boots:** Steel-toe, chemical-resistant boots OR steel-toe, leather work boots with outer rubber boot covers **Gloves:** Inner surgical-style nitrile & outer chemical-resistant nitrile gloves.	Hardhat [c] Splash shield [c] Ear protection [d] Spectacle inserts	Positive-pressure demand self-contained breathing apparatus (SCBA); MSA Ultralite, or equivalent.

Reasons for Upgrading or Downgrading Level of Protection

Upgrade[f]	Downgrade
• Request from individual performing tasks. • Change in work tasks that will increase contact or potential contact with hazardous materials. • Occurrence or likely occurrence of gas or vapor emission. • Known or suspected presence of dermal hazards. • Instrument action levels (Section 5) exceeded.	• New information indicating that situation is less hazardous than originally thought. • Change in site conditions that decreases the hazard. • Change in work task that will reduce contact with hazardous materials.

TABLE 5-1
PPE Specifications[a]

Task	Level	Body	Head	Respirator [b]

[a] Modifications are as indicated. JVII will provide PPE only to JVII employees.
[b] No facial hair that would interfere with respirator fit is permitted.
[c] Hardhat and splash-shield areas are to be determined by the SHSS.
[d] Ear protection should be worn when conversations cannot be held at distances of 3 feet or less without shouting.
[e] Cartridge change-out schedule is at least every 8 hours (or one work day), except if relative humidity is > 85%, or if organic vapor measurements are > midpoint of Level C range (refer to Section 5)--then at least every 4 hours. If encountered conditions are different than those anticipated in this HSP, contact the HSM.
[f] Performing a task that requires an upgrade to a higher level of protection (e.g., Level D to Level C) is permitted only when the PPE requirements have been approved by the HSM, and an SHSS qualified at that level is present.

6.0 Air Monitoring/Sampling

(Reference CH2M HILL- SOP HS-06, *Air Monitoring)*

6.1 Air Monitoring Specifications

Air Monitoring Specifications are listed in Table 6-1.

TABLE 6-1
Air Monitoring Specifications

Instrument	Tasks	Action Levels[a]		Frequency [b]	Calibration
PID: OVM with 10.6eV lamp or equivalent	Intrusive tasks (Installation of wells, groundwater monitoring)	0-1 ppm 1-5 ppm	Level D Level C with vinyl chloride, detector tube monitoring or suspend operations and allow vapors to dissipate to <1 ppm before continuing in Level D. If vinyl chloride reading is negative, continue level D up to 5 ppm.	Initially and periodically during task	Daily
CGI: MSA model 260 or 261 or equivalent	Intrusive Activities	0-10% : 10-25% LEL: >25% LEL:	No explosion hazard Potential explosion hazard Explosion hazard; evacuate or vent	Continuous during advancement of boring or trench	Daily
O_2Meter: MSA model 260 or 261 or equivalent	Intrusive Activities	>25%[c] O_2: 20.9%[c] O_2: <19.5%[c] O_2:	Explosion hazard; evacuate or vent Normal O_2 O_2 deficient; vent or use SCBA	Continuous during advancement of boring or trench	Daily
Dust Monitor Visual Assessment	All activities	No Visible Dust Visible Dust	Level D Use dust suppression methods	Initially and periodically during tasks	Zero Daily
Detector Tube: Drager vinyl chloride specific (0.5 to 30 ppm range) with pre-tube, or equivalent	All Intrusive Activities	<0.5 ppm 0.5-1 ppm >1 ppm	Level D Level C or allow to dissipate See FID action above	Initially and periodically when PID/FIB >1 ppm	Not applicable
Nose-Level Monitor [e]:		<85 dB(A) 85-120 dB(A) 120 dB(A)	No action required Hearing protection required Stop; re-evaluate	Initially and periodically during task	Daily

[a] Action levels apply to sustained breathing-zone measurements above background.
[b] The exact frequency of monitoring depends on field conditions and is to be determined by the SHSS; generally, every 5 to 15 minutes if acceptable; more frequently may be appropriate. Monitoring results should be recorded. Documentation should include instrument and calibration information, time, measurement results, personnel monitored, and place/location where measurement is taken (e.g., "Breathing Zone/MW-3", "at surface/SB-2", etc.).
[c] If the measured percent of O_2 is less than 10, an accurate LEL reading will not be obtained. Percent LEL and percent O_2 action levels apply only to ambient working atmospheres, and not to confined-space entry. More-stringent percent LEL and O_2 action levels are required for confined-space entry (refer to Section 2).
[d] Refer to SOP HS-10 for instructions and documentation on radiation monitoring and screening.
[e] Noise monitoring and audiometric testing also required.

6.2 Calibration Specifications

(Refer to the respective manufacturer's instructions for proper instrument-maintenance procedures)

Air Monitoring equipment calibration specifications are listed in Table 6-2

TABLE 6-2
Air Monitoring Equipment Calibration Specifications

Instrument	Gas	Span	Reading	Method
PID: OVM, 10.6 or 11.8 eV bulb	100 ppm isobutylene	RF = 1.0	100 ppm	1.5 lpm reg T-tubing
PID: MiniRAE, 10.6 eV bulb	100 ppm isobutylene	CF = 100	100 ppm	1.5 lpm reg T-tubing
PID: TVA 1000	100 ppm isobutylene	CF = 1.0	100 ppm	1.5 lpm reg T-tubing
FID: OVA	100 ppm methane	3.0 $\pm$ 1.5	100 ppm	1.5 lpm reg T-tubing
FID: TVA 1000	100 ppm methane	NA	100 ppm	2.5 lpm reg T-tubing
Dust Monitor: Miniram-PDM3	Dust-free air	Not applicable	0.00 mg/m^3 in "Measure" mode	Dust-free area OR Z-bag with HEPA filter
CGI: MSA 260, 261, 360, or 361	0.75% pentane	N/A	50% LEL $\pm$ 5% LEL	1.5 lpm reg direct tubing

6.3 Air Sampling

Sampling, in addition to real-time monitoring, may be required by other OSHA regulations where there may be exposure to certain contaminants. Air sampling typically is required when site contaminants include lead, cadmium, arsenic, asbestos, and certain volatile organic compounds. Contact the HSM immediately if these contaminants are encountered.

7.0 Decontamination

(Reference CH2M HILL- SOP HS-13, *Decontamination*)

The SHSS must establish and monitor the decontamination procedures and their effectiveness. Decontamination procedures found to be ineffective will be modified by the SHSS. The SHSS must ensure that procedures are established for disposing of materials generated on the site.

7.1 Decontamination Specifications

Personnel	Sample Equipment	Heavy Equipment
• Boot wash/rinse • Glove wash/rinse • Outer-glove removal • Body-suit removal • Inner-glove removal • Respirator removal • Hand wash/rinse • Face wash/rinse • Shower ASAP • Dispose of PPE in municipal trash, or contain for disposal • Dispose of personnel rinse water to facility or sanitary sewer, or contain for offsite disposal	• Wash/rinse equipment • Solvent-rinse equipment • Contain solvent waste for offsite disposal	• Power wash • Steam clean • Dispose of equipment rinse water to facility or sanitary sewer, or contain for offsite disposal

7.2 Diagram of Personnel-Decontamination Line

No eating, drinking, or smoking is permitted in contaminated areas and in exclusion or decontamination zones. The SHSS should establish areas for eating, drinking, and smoking. Contact lenses are not permitted in exclusion or decontamination zones.

Figure 7-1 illustrates a conceptual establishment of work zones, including the decontamination line. Work zones are to be modified by the SHSS to accommodate task-specific requirements.

Notes:
1. This figure can be used as a guide to establish a decontamination line when used PPE will either be disposed of or re-used, and can be applied to any level of protection.
2. The stations illustrated below may be removed when not applicable (e.g., no respirator station if not wearing Level C).
3. The SHSS may modify the decontamination sequence based on site-specific conditions.

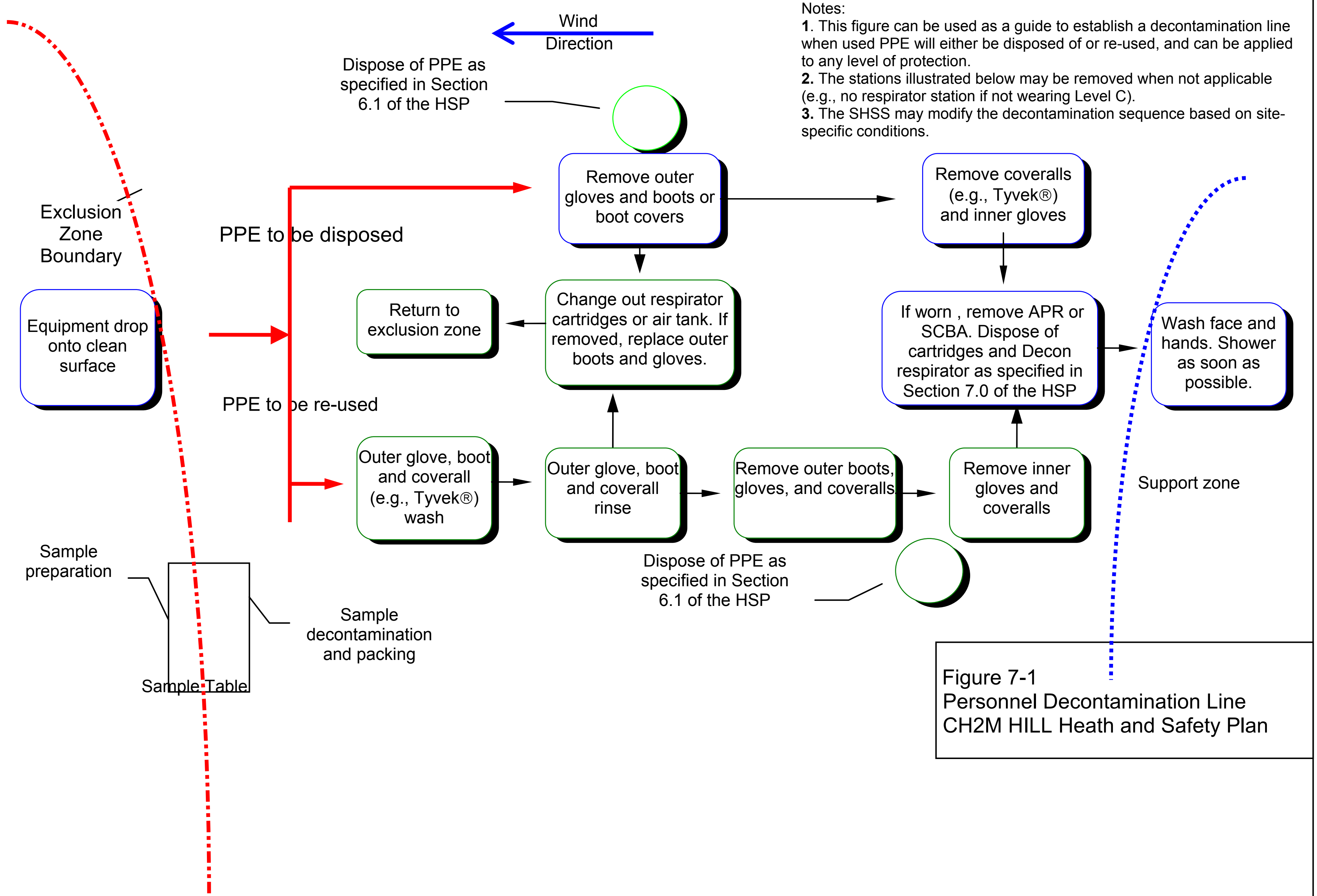


Figure 7-1
Personnel Decontamination Line
CH2M HILL Heath and Safety Plan

8.0 Spill-Containment Procedures

Sorbent material will be maintained in the support zone. Incidental spills will be contained with sorbent and disposed of properly.

9.0 Site-Control Plan

9.1 Site-Control Procedures

(Reference CH2M HILL- SOP HS-11, *Site Control)*

- The SHSS will conduct a site safety briefing (see below) before starting field activities or as tasks and site conditions change.
- Topics for briefing on site safety: general discussion of Health and Safety Plan, site-specific hazards, locations of work zones, PPE requirements, equipment, special procedures, emergencies.
- The SHSS records attendance at safety briefings in a logbook and documents the topics discussed.
- Post the OSHA job-site poster in a central and conspicuous location in accordance with CH2M HILL- SOP HS-71, OSHA Postings.
- Establish support, decontamination, and exclusion zones. Delineate with flags or cones as appropriate. Support zone should be upwind of the site. Use access control at entry and exit from each work zone.
- Establish onsite communication consisting of the following:
  - Line-of-sight and hand signals
  - Air horn
  - Two-way radio or cellular telephone if available
- Establish offsite communication.
- Establish and maintain the "buddy system."
- Initial air monitoring is conducted by the SHSS in appropriate level of protection.
- The SHSS is to conduct periodic inspections of work practices to determine the effectiveness of this plan (refer to Sections 2 and 3). Deficiencies are to be noted, reported to the HSM, and corrected.

9.2 Hazwoper Compliance Plan

(Reference CH2M HILL- SOP HS-19, *Site-Specific Written Safety Plans)*

Certain parts of the site work are covered by state or federal Hazwoper standards and therefore require training and medical monitoring. Anticipated Hazwoper tasks might occur consecutively or concurrently with respect to non-Hazwoper tasks. This section outlines procedures to be followed when approved activities do not require 24- or 40-hour training. Non-Hazwoper-trained personnel also must be trained in accordance with all other state and federal OSHA requirements.

- In many cases, air sampling, in addition to real-time monitoring, must confirm that there is no exposure to gases or vapors before non-Hazwoper-trained personnel are allowed on the site, or while non-Hazwoper-trained staff are working in proximity to Hazwoper activities. Other data (e.g., soil) also must document that there is no potential for exposure. The HSM must approve the interpretation of these data.

- When non-Hazwoper-trained personnel are at risk of exposure, the SHSS must post the exclusion zone and inform non-Hazwoper-trained personnel of the:

    - nature of the existing contamination and its locations
    - limitations of their access
    - emergency action plan for the site

- Periodic air monitoring with direct-reading instruments conducted during regulated tasks also should be used to ensure that non-Hazwoper-trained personnel (e.g., in an adjacent area) are not exposed to airborne contaminants.

- When exposure is possible, non-Hazwoper-trained personnel must be removed from the site until it can be demonstrated that there is no longer a potential for exposure to health and safety hazards.

- Remediation treatment system start-ups: Once a treatment system begins to pump and treat contaminated media, the site is, for the purposes of applying the Hazwoper standard, considered a treatment, storage, and disposal facility (TSDF). Therefore, once the system begins operation, only Hazwoper-trained personnel (minimum of 24 hours of training) will be permitted to enter the site. All non-Hazwoper-trained personnel must not enter the TSDF area of the site.

10.0 Emergency Response Plan

(Reference CH2M HILL- SOP HS-12, *Emergency Response*)

10.1 Pre-Emergency Planning

The SHSS performs the applicable pre-emergency planning tasks before starting field activities and coordinates emergency response with CH2M HILL onsite parties, the facility, and local emergency-service providers as appropriate.

- Review the facility emergency and contingency plans where applicable.
- Determine what onsite communication equipment is available (e.g., two-way radio, air horn).
- Determine what offsite communication equipment is needed (e.g., nearest telephone, cell phone).
- Confirm and post emergency telephone numbers, evacuation routes, assembly areas, and route to hospital; communicate the information to onsite personnel.
- Field Trailers: Post "Exit" signs above exit doors, and post "Fire Extinguisher" signs above locations of extinguishers. Keep areas near exits and extinguishers clear.
- Review changed site conditions, onsite operations, and personnel availability in relation to emergency response procedures.
- Where appropriate and acceptable to the client, inform emergency room and ambulance and emergency response teams of anticipated types of site emergencies.
- Designate one vehicle as the emergency vehicle; place hospital directions and map inside; keep keys in ignition during field activities.
- Inventory and check site emergency equipment, supplies, and potable water.
- Communicate emergency procedures for personnel injury, exposures, fires, explosions, and releases.
- Rehearse the emergency response plan before site activities begin, including driving route to hospital.
- Brief new workers on the emergency response plan.
- The SHSS will evaluate emergency response actions and initiate appropriate follow-up actions.

10.2 Emergency Equipment and Supplies

The SHSS should mark the locations of emergency equipment on the site map and post the map.

Emergency Equipment and Supplies	Location
20 LB (or two 10-lb) fire extinguisher (A, B, and C classes)	Support Zone/Heavy Equipment
First aid kit	Support Zone/Field Vehicle
Eye Wash	Support & Decon Zone/Field Vehicle
Potable water	Support & Decon Zone/Field Vehicle
Bloodborne-pathogen kit	Support Zone/Field Vehicle

10.3 Incident Reporting, Investigation and Response

For any accident meeting the definition of Recordable Occupational Injuries or Illnesses or Significant Accidents, the Southern Division, NAVFAC Contracting Officer and Navy Technical Representative (NTR) shall be notified by the HSM or Program Manager soon as practical, but not later than four hours after occurrence. All other incidents must be reported to Southern Division, NAVFAC within 24 hours of incident occurrence.

Therefore in order for the incident to be assessed for reportability purposes it is imperative that according to CH2M HILL requirements, all personal injuries, near-misses, or property damage incidents involving CH2M HILL or subcontractor project personnel be reported IMMEDIATELY to the HSM Rich Rathnow/ORO, Program Manager Scott Newman/ATL, or CH2M HILL Corporate HSM Angelo Liberatore/ATL at the numbers identified in the emergency contact attachment contained in this plan.

The Site Manager or designee must report the following incident information to the HSM immediately after incident occurrence:

- Date and time of mishap
- Project name and project number
- Name and worker classification
- Extent of known injuries
- Level of medical attention
- Injury cause

A written incident investigation shall be performed and submitted to the HSM within 24 hours of incident occurrence by the completing the Incident Report, Near Loss Investigation and Root Cause Analysis provided in the HSP Attachments.

In fires, explosions, or chemical releases, actions to be taken include the following:

Shut down JVII operations and evacuate the immediate work area.
Notify appropriate response personnel.
Account for personnel at the designated assembly area(s).

Assess the need for site evacuation, and evacuate the site as warranted.

Instead of implementing a work-area evacuation, note that small fires or spills posing minimal safety or health hazards may be controlled.

10.4 Emergency Medical Treatment

The procedures listed below may also be applied to non-emergency incidents. JVII employee injuries and illnesses must be reported to the Human Resource contact in Attachment 4. If there is doubt about whether medical treatment is necessary, or if the injured person is reluctant to accept medical treatment, contact the JVII medical consultant, depending on whose employee is injured. During non-emergencies, follow these procedures as appropriate.

- Notify appropriate emergency response authorities (e.g., 911).
- The SHSS will assume charge during a medical emergency until the ambulance arrives or until the injured person is admitted to the emergency room.
- Prevent further injury.
- Initiate first aid and CPR where feasible.
- Get medical attention immediately.
- Perform decontamination where feasible; lifesaving and first aid or medical treatment take priority.
- Make certain that the injured person is accompanied to the emergency room.
- When contacting the medical consultant, give your name and telephone number, the name of the injured person, the extent of the injury or exposure, and the name and location of the medical facility where the injured person was taken.
- Report incident as outlined in Section 10.7.

10.5 Evacuation

- Evacuation routes and assembly areas (and alternative routes and assembly areas) are specified on the site map.
- Evacuation route(s) and assembly area(s) will be designated by the SHSS before work begins.
- Personnel will assemble at the assembly area(s) upon hearing the emergency signal for evacuation.
- The SHSS and a “buddy” will remain on the site after the site has been evacuated (if safe) to assist local responders and advise them of the nature and location of the incident.
- The SHSS will account for all personnel in the onsite assembly area.

- A designated person will account for personnel at alternate assembly area(s).
- The SHSS will write up the incident as soon as possible after it occurs and submit a report to the Corporate Director of Health and Safety.

10.6 Evacuation Signals

Signal	Meaning
Grasping throat with hand	Emergency-help me.
Thumbs up	OK; understood.
Grasping buddy’s wrist	Leave area now.
Continuous sounding of horn	Emergency; leave site now.

10.7 Incident Notification and Reporting

- Upon any project incident (fire, spill, injury, near miss, death, etc.), immediately notify the PM and HSM. Call emergency beeper number if HSM is unavailable.
- For JVII work-related injuries or illnesses, contact the respective Human Resources contact listed in Attachment 4. For JVII incidents the HR administrator completes an Incident Report Form (IRF). IRF must be completed within 24 hours of incident.
- For JVII subcontractor incidents, complete the Subcontractor Accident/Illness Report Form (Attachment)and submit to the HSM.
- Notify and submit reports to client as required in contract.

11.0 Behavior Based Loss Prevention System

A Behavior Based Loss Prevention System (BBLPS) is a system to prevent or reduce losses using behavior-based tools and proven management techniques to focus on behaviors or acts that could lead to losses.

The four basic Loss Prevention tools that will be used on EE&S CH2M HILL projects to implement the BBLPS include:

- Activity Hazard Analysis (AHA)
- Pre-Task Safety Plans (PTSP)
- Loss Prevention Observations (LPO)
- Loss and Near Loss Investigations (NLI)

The Site Supervisor serves as the Site Health and Safety Specialist (SHSS) and is responsible for implementing the BBLPS on the project site. When a separate individual is assigned as the SHSS, the SHSS is delegated authority from the Site Supervisor to implement the BBLPS on the project site, but the Site Supervisor remains accountable for it's implementation. The Site Supervisor/Safety Coordinator shall only oversee the subcontractor's implementation of their AHAs and PTSPs processes on the project.

11.1 Activity Hazard Analysis

An Activity Hazard Analysis (AHA) defines the activity being performed, the hazards posed and control measures required to perform the work safely. Workers are briefed on the AHA before doing the work and their input is solicited prior, during and after the performance of work to further identify the hazards posed and control measures required.

Activity Hazard Analysis will be prepared before beginning each project activity posing H&S hazards to project personnel using the AHA form provided in Attachment 6. The AHA shall identify the work tasks required to perform each activity, along with potential H&S hazards and recommended control measures for each work task. In addition, a listing of the equipment to be used to perform the activity, inspection requirements and training requirements for the safe operation of the equipment listed must be identified.

An AHA shall be prepared for all field activities performed by CH2M HILL and subcontractor during the course of the project by the Site Supervisor/SHSS. The Project-Specific and General Hazards of the HSP, the Hazard Analysis Table (Table 2-1), and applicable CH2M HILL Standards of Practice (SOPs) should be used as a basis for preparing JVII AHAs.

CH2M HILL subcontractors are required to provide AHAs specific to their scope of work on the project for acceptance by JVII. Each subcontractor shall submit AHAs for their field activities, as defined in their work plan/scope of work, along with their project-specific HSP. Additions or changes in JVII or subcontractor field activities, equipment, tools or material to perform work or additional/different hazard encountered that require additional/different hazard control measures requires either a new AHA to be prepared or an existing AHA to be revised.

11.2 Pre-Task Safety Plans

Daily safety meetings are held with all project personnel in attendance to review the hazards posed and required H&S procedures/AHAs, that apply for each day's project activities. The PTSPs serve the same purpose as these general assembly safety meetings, but the PTSPs are held between the crew supervisor and their work crews to focus on those hazards posed to individual work crews. At the start of each day's activities, the crew supervisor completes the PTSP, provided in Attachment 6, with input from the work crew, during their daily safety meeting. The day's tasks, personnel, tools and equipment that will be used to perform these tasks are listed, along with the hazards posed and required H&S procedures, as identified in the AHA. The use of PTSPs, better promotes worker participation in the hazard recognition and control process, while reinforcing the task-specific hazard and required H&S procedures with the crew each day. The use of PTSPs is a common safety practice in the construction industry.

11.3 Loss Prevention Observations

Loss Prevention Observations (LPOs) shall be conducted by Site Supervisor/SHSS for specific work tasks or operations comparing the actual work process against established safe work procedures identified in the project-specific HSP and AHAs. LPOs are a tool to be used by supervisors to provide positive reinforcement for work practices performed correctly, while also identifying and eliminating deviations from safe work procedures that could result in a loss. Site Supervisor/SHSS shall perform at least one LPO each week for a tasks/operations addressed in the project-specific HSP or AHA. The Site Supervisor/SHSS shall complete the LPO form in Attachment 6 for the task/operation being observed.

11.4 Loss/Near Loss Investigations

Loss/Near Loss Investigations shall be performed for the all JVII and subcontractor incidents involving:

- Person injuries/illnesses and near miss injuries
- Equipment/property damage
- Spills, leaks, regulatory violations
- Motor vehicle accidents

The cause of loss and near loss incidents are similar, so by identifying and correcting the causes of near loss causes, future loss incidents may be prevented. The following is the Loss/Near Loss Investigation Process:

- Gather all relevant facts, focusing on fact-finding, not fault-finding, while answering the who, what, when, where and how questions.

- Draw conclusions, pitting facts together into a probable scenario.

- Determine incident root cause(s), which are basic causes on why an unsafe act/condition existed.

- Develop and implement solutions, matching all identified root causes with solutions.

- Communicate incident as a Lesson Learned to all project personnel.

- Filed follow-up on implemented corrective active action to confirm solution is appropriate.

Site Supervisors/SHSS shall perform an incident investigation, as soon as practical after incident occurrence during the day of the incident, for all Loss and Near Loss Incidents that occur on the project. Loss and Near Loss incident investigations shall be performed using the following incident investigation forms provided in Attachment 6:

- Incident Report Form (IRF)
- Incident Investigation Form
- Root Cause Analysis Form

All Loss and Near Loss incident involving personal injury, property damage in excess of $1,000 or near loss incidents that could have resulted in serious consequences shall be investigated by completing the incident investigation forms and submitting them to the PM and HSM within 24 hours of incident occurrence. A preliminary Incident Investigation and Root Cause Analysis shall be submitted to the Project Manager and HSM within 24 hours of incident occurs. The final Incident Investigation and Root Cause Analysis shall be submitted after completing a comprehensive investigation of the incident.

12.0 Approval

This site-specific Health and Safety Plan has been written for use by JVII only. JVII claims no responsibility for its use by others unless that use has been specified and defined in project or contract documents. The plan is written for the specific site conditions, purposes, dates, and personnel specified and must be amended if those conditions change.

12.1 Original Plan

Written By: Terry McElveen **Date: 7-15-05**

Approved By: Richard Rathnow, CIH **Date: 7-25-05**

12.2 Revisions

Revisions Made By: **Date:**

Revisions to Plan:

Revisions Approved By: **Date:**

Attachment 1

Employee Signoff Form

EMPLOYEE SIGNOFF FORM

Health and Safety Plan

The JVII project employees and subcontractors listed below have been provided with a copy of this HSP, have read and understood it, and agree to abide by its provisions.

Project Name: **Project Number:**

EMPLOYEE NAME (Please print)	**EMPLOYEE SIGNATURE**	**COMPANY**	**DATE**

Attachment 2

Project-Specific Chemical Product Hazard Communication Form

Project-Specific Chemical Product Hazard Communication Form

This form must be completed prior to performing activities that expose personnel to hazardous chemicals products. Upon completion of this form, the SHSS shall verify that training is provided on the hazards associated with these chemicals and the control measures to be used to prevent exposure to JVII and subcontractor personnel. Labeling and MSDS systems will also be explained.

Project Name: **Project Number:**

MSDSs will be maintained at the following location(s):

Hazardous Chemical Products Inventory

Chemical	Quantity	Location	MSDS Available	Container labels	
				Identity	Hazard
Methane	1 liter, compressed	Support Zone			
Isobutylene	1 liter, compressed	Support Zone			
Pentane	1 liter, compressed	Support Zone			
Hydrochloric acid	< 500 ml	Support Zone / sample bottles			
Nitric acid	< 500 ml	Support Zone / sample bottles			
Sulfuric Acid	< 500 ml	Support Zone / sample bottles			
Sodium hydroxide	< 500 ml	Support Zone / sample bottles			
Methanol	< 1 Gallon	Support/Decon Zones			
Hexane	< 1 Gallon	Support/Decon Zones			
pH buffers	< 500 ml	Support Zone			
MSA Sanitizer	< 1 liter	Support/Decon Zones			
Alconox/Liquinox	< 1liter	Support/Decon Zones			

Refer to SOP HS-05 *Hazard Communication* for more detailed information.

Attachment 3

Chemical Specific Training Form

CHEMICAL-SPECIFIC TRAINING FORM

Location:	Project # :
SHSS:	Trainer:

TRAINING PARTICIPANTS:

NAME	SIGNATURE	NAME	SIGNATURE

REGULATED PRODUCTS/TASKS COVERED BY THIS TRAINING:

The HCC shall use the product MSDS to provide the following information concerning each of the products listed above.

- ☐ Physical and health hazards
- ☐ Control measures that can be used to provide protection (including appropriate work practices, emergency procedures, and personal protective equipment to be used)
- ☐ Methods and observations used to detect the presence or release of the regulated product in the workplace (including periodic monitoring, continuous monitoring devices, visual appearance or odor of regulated product when being released, etc.)

Training participants shall have the opportunity to ask questions concerning these products and, upon completion of this training, will understand the product hazards and appropriate control measures available for their protection.

Copies of MSDSs, chemical inventories, and JVII's written hazard communication program shall be made available for employee review in the facility/project hazard communication file.

Attachment 4

Emergency Contacts

Emergency Contacts-

24-hour CH2M HILL Emergency Beeper – 888/444-1226

Medical Emergency – 911 Facility Medical Response #: Local Ambulance #:	**CH2M HILL- Medical Consultant** Dr. Jerry H. Berke, M.D., M.P.H. Health Resources 600 West Cummings Park, Suite 3400 Woburn, MA 01801-6350 781/938-4653 800/350-4511 (After hours calls will be returned within 20 minutes)
Fire/Spill Emergency -- 911 Facility Fire Response #: Local Fire Dept #:	**Local Occupational Physician**
	JVII Program Manager Name: Joe Collela AGVIQ Phone: 770/604-9182 Mobile: 412-915-1221
Security & Police – 911 Facility Security #: Local Police #:	**JVII Deputy Program Manager** Name: Scott Smith/ATL Phone: 770/604/9182 Mobile: 404-433-6090
Utilities Emergency Water: Gas: Electric:	**Navy RAC Health and Safety Manager (HSM)** Name: Rich Rathnow/ORO Phone: 865/483-9005 (Office); 865/607-6734 (Cell) 865/531-2933 (Home)
Site Health and Safety Specialist (SHSS) Name: Phone:	**CH2M HILL Human Resources Department** Name: Nancy Orr/COR Phone: 303/771-0952
Project Manager Name: Sam Naik Phone: (770) 604-9182 x255 Mobile: 678-860-9626	**Corporate Human Resources Department** Name: John Monark/COR Phone: 303/771-0900
Federal Express Dangerous Goods Shipping Phone: 800/238-5355 **Emergency Number for Shipping Dangerous Goods** Phone: 800/255-3924	**CH2M HILL Worker's Compensation and Auto Claims** Sterling Administration Services Phone: 800/420-8926 After hours: 800/497-4566 Report fatalities AND report vehicular accidents involving pedestrians, motorcycles, or more than two cars.

Contact the Project Manager. Generally, the Project Manager will contact relevant government agencies.

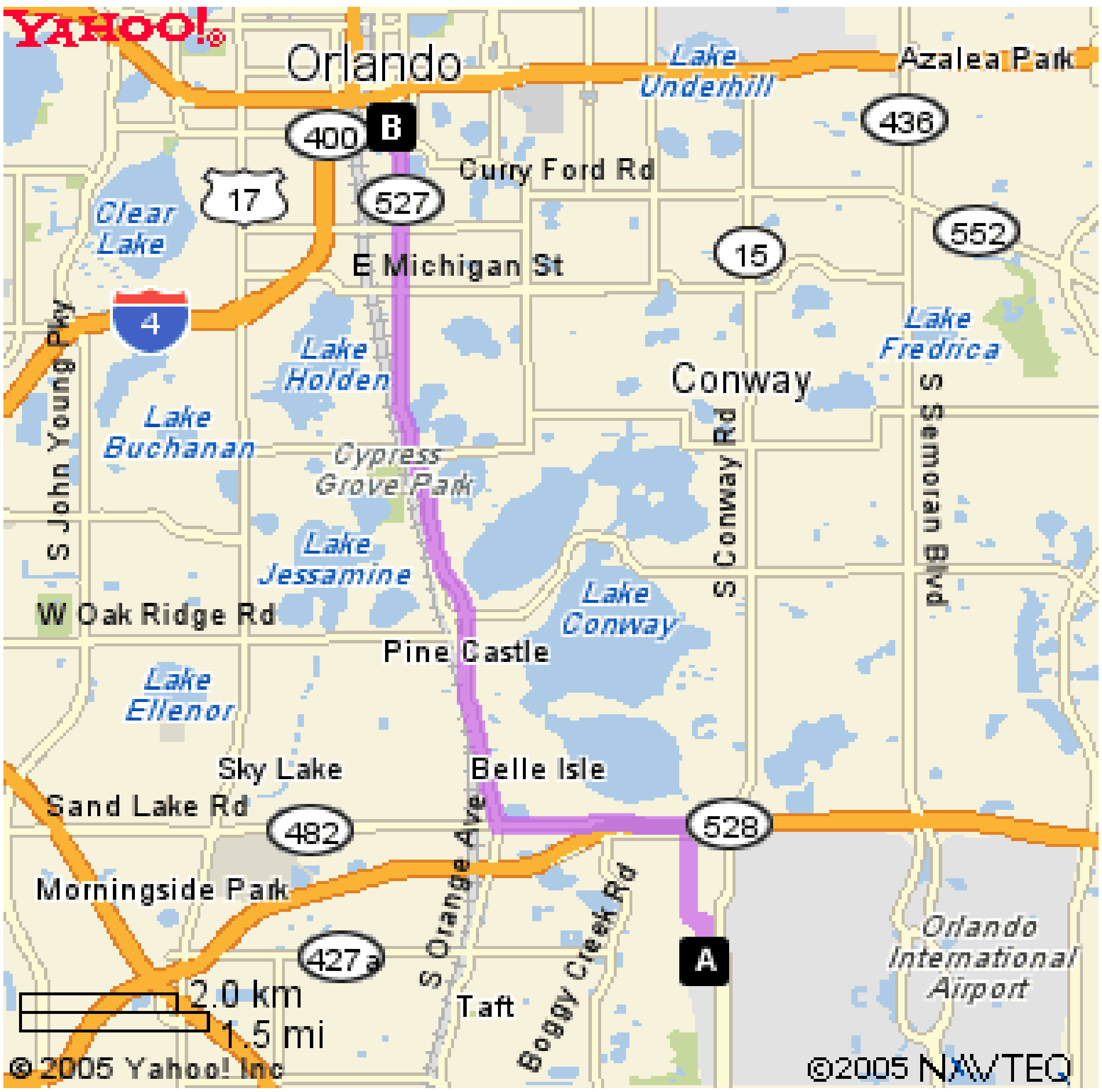
Facility Alarms:	**Evacuation Assembly Area(s):**
Hospital Name/Address: **Orlando Regional Lucerne**	**Hospital Phone #:** (407) 649-6111

Directions to Hospital

See map next page

ORLANDO REGIONAL LUCERNE
818 MAIN LN
ORLANDO, FL
Phone: (407) 649-6111

1. Start on **AVENUE C** (at AVENUE C & BINNACLE WAY) - go 0.3 mi
2. Turn **Left** on **4TH ST** - go 0.1 mi
3. Turn **Right** on **DAETWYLER DR** - go 0.7 mi
4. Turn **Left** on **MCCOY RD** - go 1.5 mi
5. Turn **Right** on **S ORANGE AVE**[FL-527] - go 1.2 mi
6. Bear **Right** to follow **FL-527 NORTH** - go 4.4 mi
7. Turn **Left** on **W GORE ST** - go 0.1 mi
8. Turn **Right** on **MAIN LN** - go < 0.1 mi
9. Arrive at **ORLANDO REGIONAL LUCERN**



Attachment 5

Project Activity Self-Assessment Checklists/Permits

Drilling

Hand and Power Tools

HS&E Self-Assessment Checklist - DRILLING

This checklist shall be used by CH2M HILL personnel **only** and shall be completed at the frequency specified in the project's written safety plan.

This checklist is to be used at locations where: 1) CH2M HILL employees are potentially exposed to drilling hazards, 2) CH2M HILL staff are providing support function related to drilling activities, and/or 3) CH2M HILL oversight of a drilling subcontractor is required.

Safety Coordinator may consult with drilling subcontractors when completing this checklist, but shall not direct the means and methods of drilling operations nor direct the details of corrective actions. Drilling subcontractors shall determine how to correct deficiencies and we must carefully rely on their expertise. Items considered to be imminently dangerous (possibility of serious injury or death) shall be corrected immediately, or all exposed personnel shall be removed from the hazard until corrected.

Project Name: ____ Project No.: __________________

Location: ____ PM: _____________________________

Auditor: ______________________________ Title: ____________________________ Date: ___________

This specific checklist has been completed to:

☐ Evaluate CH2M HILL employee exposures to drilling hazards (complete Section 1).
☐ Evaluate CH2M HILL support functions related to drilling activities (complete Section 2)
☐ Evaluate a CH2M HILL subcontractor's compliance with drilling safety requirements (complete entire checklist).
Subcontractors Name: ____

- Check "Yes" if an assessment item is complete/correct.
- Check "No" if an item is incomplete/deficient. Deficiencies shall be brought to the immediate attention of the drilling subcontractor. Section 3 must be completed for all items checked "No."
- Check "N/A" if an item is not applicable.
- Check "N/O" if an item is applicable but was not observed during the assessment.

Numbers in parentheses indicate where a description of this assessment item can be found in SOP HSE-35.

SECTION 1 - SAFE WORK PRACTICES (4.1)

	Yes	No	N/A	N/O
1. Personnel cleared during rig startup	☐	☐	☐	☐
2. Personnel clear of rotating parts	☐	☐	☐	☐
3. Personnel not positioned under hoisted loads	☐	☐	☐	☐
4. Loose clothing and jewelry removed	☐	☐	☐	☐
5. Smoking is prohibited around drilling operation	☐	☐	☐	☐
6. Personnel wearing appropriate personal protective equipment (PPE), per written plan	☐	☐	☐	☐
7. Personnel instructed not to approach equipment that has become electrically energized	☐	☐	☐	☐

SECTION 2 - SUPPORT FUNCTIONS (4.2)

FORMS/PERMITS (4.2.1)

	Yes	No	N/A	N/O
8. Driller license/certification obtained	☐	☐	☐	☐
9. Well development/abandonment notifications and logs submitted and in project files	☐	☐	☐	☐
10. Water withdrawal permit obtained, where required	☐	☐	☐	☐
11. Dig permit obtained, where required	☐	☐	☐	☐

UTILITY LOCATING (4.2.2)

	Yes	No	N/A	N/O
12. Location of underground utilities and structures identified	☐	☐	☐	☐

SECTION 2 (Continued)

	Yes	No	N/A	N/O
WASTE MANAGEMENT (4.2.3)				
13. Drill cuttings and purge water managed and disposed properly	☐	☐	☐	☐
DRILLING AT HAZARDOUS WASTE SITES (4.2.4)				
14. Waste disposed of according to project's written safety plan	☐	☐	☐	☐
15. Appropriate decontamination procedures being followed, per project's written safety plan	☐	☐	☐	☐
DRILLING AT ORDNANCE EXPLOSIVES (OE)/UNEXPLODED ORDNANCE (UXO) SITES (4.2.5)				
16. OE plan prepared and approved	☐	☐	☐	☐
17. OE/UXO avoidance provided, routes and boundaries cleared and marked	☐	☐	☐	☐
18. Initial pilot hole established by UXO technician with hand auger	☐	☐	☐	☐
19. Personnel remain inside cleared areas	☐	☐	☐	☐
SECTION 3 - DRILLING SAFETY REQUIREMENTS (4.3)				
GENERAL (4.3.1)				
20. Only authorized personnel operating drill rigs	☐	☐	☐	☐
21. Daily safety briefing/meeting conducted with crew	☐	☐	☐	☐
22. Daily inspection of drill rig and equipment conducted before use	☐	☐	☐	☐
DRILL RIG PLACEMENT (4.3.2)				
23. Location of underground utilities and structures identified	☐	☐	☐	☐
24. Safe clearance distance maintained from overhead power lines	☐	☐	☐	☐
25. Drilling pad established, when necessary	☐	☐	☐	☐
26. Drill rig leveled and stabilized	☐	☐	☐	☐
27. Additional precautions taken when drilling in confined areas	☐	☐	☐	☐
DRILL RIG TRAVEL (4.3.3)				
28. Rig shut down and mast lowered and secured prior to rig movement	☐	☐	☐	☐
29. Tools and equipment secured prior to rig movement	☐	☐	☐	☐
30. Only personnel seated in cab are riding on rig during movement	☐	☐	☐	☐
31. Safe clearance distance maintained while traveling under overhead power lines	☐	☐	☐	☐
32. Backup alarm or spotter used when backing rig	☐	☐	☐	☐
DRILL RIG OPERATION (4.3.4)				
33. Kill switch clearly identified and operational	☐	☐	☐	☐
34. All machine guards are in place	☐	☐	☐	☐
35. Rig ropes not wrapped around body parts	☐	☐	☐	☐
36. Pressurized lines and hoses secured from whipping hazards	☐	☐	☐	☐
37. Drill operation stopped during inclement weather	☐	☐	☐	☐
38. Air monitoring conducted per written safety plan for hazardous atmospheres	☐	☐	☐	☐
39. Rig placed in neutral when operator not at controls	☐	☐	☐	☐
DRILL RIG SITE CLOSURE (4.3.5)				
40. Ground openings/holes filled or barricaded	☐	☐	☐	☐
41. Equipment and tools properly stored	☐	☐	☐	☐
42. All vehicles locked and keys removed	☐	☐	☐	☐
DRILL RIG MAINTENANCE (4.3.6)				
28. Defective components repaired immediately	☐	☐	☐	☐
29. Lockout/tagout procedures used prior to maintenance	☐	☐	☐	☐
30. Cathead in clean, sound condition	☐	☐	☐	☐
31. Drill rig ropes in clean, sound condition	☐	☐	☐	☐
32. Fall protection used for fall exposures of 6 feet (U.S.) 1.5 meters (Australia) or greater	☐	☐	☐	☐
33. Rig in neutral and augers stopped rotating before cleaning	☐	☐	☐	☐
34. Good housekeeping maintained on and around rig	☐	☐	☐	☐

SECTION 4

Complete this section for all items checked "No" in previous sections. Deficient items must be corrected in a timely manner.

Item #	Corrective Action Planned/Taken	Date Corrected

Auditor: _________________________________ Project Manager: ___________________________________

H&S Self-Assessment Checklist – HAND AND POWER TOOLS

This checklist shall be used by CH2M HILL personnel **only** and shall be completed at the frequency specified in the project's HSP/FSI.

This checklist is to be used at locations where: 1) CH2M HILL employees are exposed to hand and power tool hazards and/or 2) CH2M HILL provides oversight of subcontractor personnel who are exposed to hand and power tool hazards.

SSC or DSC may consult with subcontractors when completing this checklist, but shall not direct the means and methods of hand and power tool use nor direct the details of corrective actions. Subcontractors shall determine how to correct deficiencies and we must carefully rely on their expertise. Items considered to be imminently dangerous (possibility of serious injury or death) shall be corrected immediately or all exposed personnel shall be removed from the hazard until corrected.

Completed checklists shall be sent to the HS&E Staff for review.

Project Name: ____ Project No.: ____________________

Location: ____ PM: ______________________________

Auditor: ________________________________ Title: _____________________________ Date: ____________

This specific checklist has been completed to:

☐ Evaluate CH2M HILL employee exposure to hand and power tool hazards.
☐ Evaluate a CH2M HILL subcontractor's compliance with hand and power tool requirements.
Subcontractors Name: ____

- Check "Yes" if an assessment item is complete/correct.
- Check "No" if an item is incomplete/deficient. Deficiencies shall be brought to the immediate attention of the subcontractor. Section 3 must be completed for all items checked "No."
- Check "N/A" if an item is not applicable.
- Check "N/O" if an item is applicable but was not observed during the assessment.

Numbers in parentheses indicate where a description of this assessment item can be found in Standard of Practice HS-50.

SECTION 1

SAFE WORK PRACTICES (3.1)

	Yes	No	N/A	N/O
1. All tools operated according to manufacturer's instructions and design limitations.	☐	☐	☐	☐
2. All hand and power tools maintained in a safe condition and inspected and tested before use.	☐	☐	☐	☐
3. Defective tools are tagged and removed from service until repaired.	☐	☐	☐	☐
4. PPE is selected and used according to tool-specific hazards anticipated.	☐	☐	☐	☐
5. Power tools are not carried or lowered by their cord or hose.	☐	☐	☐	☐
6. Tools are disconnected from energy sources when not in use, servicing, cleaning, etc.	☐	☐	☐	☐
7. Safety guards remain installed or are promptly replaced after repair.	☐	☐	☐	☐
8. Tools are stored properly.	☐	☐	☐	☐
1. Cordless tools and recharging units both conform to electrical standards and specifications.	☐	☐	☐	☐
10. Tools used in explosive environments are rated for such use.	☐	☐	☐	☐
11. Knife or blade hand tools are used with the proper precautions.	☐	☐	☐	☐
12. Consider controls to avoid muscular skeletal, repetitive motion, and cumulative trauma stressors.	☐	☐	☐	☐

SECTION 2	Yes	No	N/A	N/O
GENERAL (3.2.1)				
13. PPE is selected and used according to tool-specific hazards anticipated.	☐	☐	☐	☐
14. Tools are tested daily to assure safety devices are operating properly.	☐	☐	☐	☐
15. Damaged tools are removed from service until repaired.	☐	☐	☐	☐
16. Power operated tools designed to accommodate guards have guards installed.	☐	☐	☐	☐
17. Rotating or moving parts on tools are properly guarded.	☐	☐	☐	☐
18. Machines designed for fixed locations are secured or anchored.	☐	☐	☐	☐
19. Floor and bench-mounted grinders are provided with properly positioned work rests.	☐	☐	☐	☐
20. Guards are provided at point of operation, nip points, rotating parts, etc.	☐	☐	☐	☐
21. Fluid used in hydraulic-powered tools is approved fire-resistant fluid.	☐	☐	☐	☐
ELECTRIC-POWERED TOOLS (3.2.2)				
22. Electric tools are approved double insulated or grounded and used according to SOP HS-23.	☐	☐	☐	☐
23. Electric cords are not used for hoisting or lowering tools.	☐	☐	☐	☐
24. Electric tools are used in damp/ wet locations are approved for such locations or GFCI installed.	☐	☐	☐	☐
25. Hand-held tools are equipped with appropriate on/off controls appropriate for the tool.	☐	☐	☐	☐
26. Portable, power-driven circular saws are equipped with proper guards.	☐	☐	☐	☐
ABRASIVE WHEEL TOOLS (3.2.3)				
27. All employees using abrasive wheel tools are wearing eye protection.	☐	☐	☐	☐
28. All grinding machines are supplied with sufficient power to maintain spindle speed.	☐	☐	☐	☐
29. Abrasive wheels are closely inspected and ring-tested before use.	☐	☐	☐	☐
30. Grinding wheels are properly installed.	☐	☐	☐	☐
31. Cup-type wheels for external grinding are protected by the proper guard or flanges.	☐	☐	☐	☐
32. Portable abrasive wheels used for internal grinding are protected by safety flanges.	☐	☐	☐	☐
33. Safety flanges are used only with wheels designed to fit the flanges.	☐	☐	☐	☐
34. Safety guards on abrasive wheel tools are mounted properly and of sufficient strength.	☐	☐	☐	☐
PNEUMATIC-POWERED TOOLS (3.2.4)				
35. Tools are secured to hoses or whip by positive means to prevent disconnection.	☐	☐	☐	☐
36. Safety clips or retainers are installed to prevent attachments being expelled.	☐	☐	☐	☐ 37.
Safety devices are installed on automatic fastener feed tools as required.	☐	☐	☐	☐
38. Compressed air is not used for cleaning unless reduced to < 30 psi, with PPE, and guarded.	☐	☐	☐	☐
39. Manufacturer's safe operating pressure for hoses, pipes, valves, etc. are not exceeded.	☐	☐	☐	☐
40. Hoses are not used for hoisting or lowering tools.	☐	☐	☐	☐
41. All hoses >1/2-inch diameter have safety device at source to reduce pressure upon hose failure.	☐	☐	☐	☐
42. Airless spray guns have required safety devices installed.	☐	☐	☐	☐
43. Blast cleaning nozzles are equipped with operating valves, which are held open manually.	☐	☐	☐	☐
44. Supports are provided for mounting nozzles when not in use.	☐	☐	☐	☐
45. Air receiver drains, handholes, and manholes are easily accessible.	☐	☐	☐	☐
46. Air receivers are equipped with drainpipes and valves for removal of accumulated oil and water.	☐	☐	☐	☐
47. Air receivers are completely drained at required intervals.	☐	☐	☐	☐
48. Air receivers are equipped with indicating pressure gauges.	☐	☐	☐	☐
49. Safety, indicating, and controlling devices are installed as required.	☐	☐	☐	☐
50. Safety valves are tested frequently and at regular intervals to assure good operating condition.	☐	☐	☐	☐

SECTION 2 (continued)

	Yes	No	N/A	N/O
LIQUID FUEL-POWERED TOOLS (3.2.5)				
51. Liquid fuel-powered tools are stopped when refueling, servicing, or maintaining.	☐	☐	☐	☐
51. Liquid fuels are stored, handled, and transported in accordance with SOP HS-21	☐	☐	☐	☐
51. Liquid fuel-powered tools are used in confined spaces in accordance with SOP HS-17.	☐	☐	☐	☐
51. Safe operating pressures of hoses, valves, pipes, filters, and other fittings are not exceeded.	☐	☐	☐	☐
POWDER-ACTUATED TOOLS (3.2.6)				
51. Only trained employee operates powder-actuated tools.	☐	☐	☐	☐
51. Powder-actuated tools are not loaded until just prior to intended firing time.	☐	☐	☐	☐
51. Tools are not pointed at any employee at any time.	☐	☐	☐	☐
51. Hands are kept clear of open barrel end.	☐	☐	☐	☐
51. Loaded tools are not left unattended.	☐	☐	☐	☐
51. Fasteners are not driven into very hard or brittle materials.	☐	☐	☐	☐
51. Fasteners are not driven into easily penetrated materials unless suitable backing is provided.	☐	☐	☐	☐
51. Fasteners are not driven into spalled areas.	☐	☐	☐	☐
51. Powder-actuated tools are not used in an explosive or flammable atmosphere.	☐	☐	☐	☐
51. All tools are used with correct shields, guards, or attachments recommended by manufacturer.	☐	☐	☐	☐
JACKING TOOLS (3.2.7)				
51. Rated capacities are legibly marked on jacks and not exceeded.	☐	☐	☐	☐
51. Jacks have a positive stop to prevent over-travel.	☐	☐	☐	☐
51. The base of jacks are blocked or cribbed to provide a firm foundation, when required.	☐	☐	☐	☐
51. Wood blocks are place between the cap and load to prevent slippage, when required.	☐	☐	☐	☐
51. After load is raised, it is cribbed, blocked, or otherwise secured immediately.	☐	☐	☐	☐
51. Antifreeze is used when hydraulic jacks are exposed to freezing temperatures.	☐	☐	☐	☐
51. All jacks are properly lubricated.	☐	☐	☐	☐
51. Jacks are inspected as required.	☐	☐	☐	☐
51. Repair or replacement parts are examined for possible defects.	☐	☐	☐	☐
51. Jacks not working properly are removed from service and repaired or replaced.	☐	☐	☐	☐
HAND TOOLS (3.2.8)				
51. Wrenches are not used when jaws are sprung to the point of slippage.	☐	☐	☐	☐
51. Impact tools are kept free of mushroomed heads.	☐	☐	☐	☐
51. Wooden handles of tools are kept free of splinters or cracks and are tightly fitted in tool.	☐	☐	☐	☐

SECTION 3

Complete this section for all items checked “No” in Sections 1 or 2. Deficient items must be corrected in a timely manner.

Item #	Corrective Action Planned/Taken	Date Corrected

Auditor: ___________________________________ Project Manager: ______________________________________

Attachment 6

Behavior Based Loss Prevention System Forms

Activity Hazard Analysis
Pre-Task Safety Plans
Loss Prevention Observation
Incident Report and Investigation

Activity Hazard Form

Activity:	**Date:**
	Project:
Description of the work:	**Site Supervisor:**
	Site Safety Officer:
	Review for latest use: Before the job is performed.

Work Tasks	Identify & Analyze the Hazards	Identify Hazard Controls

Work Tasks	Identify & Analyze the Hazards	Identify Hazard Controls

Equipment to be used	Inspection Requirements	Training Requirements

PRINT	SIGNATURE		
Supervisor Name:	____________________	____________________________	Date/Time:________________________________
Safety Officer Name:	____________________	____________________________	Date/Time:________________________________
Employee Name(s):	____________________	____________________________	Date/Time:________________________________
	____________________	____________________________	Date/Time:________________________________
	____________________	____________________________	Date/Time:________________________________
	____________________	____________________________	Date/Time:________________________________
	____________________	____________________________	Date/Time:________________________________
	____________________	____________________________	Date/Time:________________________________
	____________________	____________________________	Date/Time:________________________________
	____________________	____________________________	Date/Time:________________________________
	____________________	____________________________	Date/Time:________________________________
	____________________	____________________________	**Date/Time:**________________________________
	____________________	____________________________	**Date/Time:**________________________________

CH2MHILL PRE-TASK SAFETY PLAN

Project: ________________________ Location: ________________________Date:__________________________

Supervisor: ________________________________Emergency Number(s):______________________________

Brief Job Descriptions:
1.____
2.____
3.____
4.____
5.____

List Specific Tasks for the Jobs (Match number from above).
1.____
2.____
3.____
4.____
5.____

Tools/Equipment required for Tasks, (ladders, scaffolds, fall protection, cranes/rigging, heavy equipment, power tools)match number from above:
1.____
2.____
3.____
4.____
5.____

Potential H&S Hazards, including chemical, physical, safety, biological and environmental **(Check all that apply and review exposures as they will be encountered in the tasks above):**

__ Chemical burns/contact	__ Trench, excavations, cave-ins	__Ergonomics
__ Pressurized lines/equipment	__ Overexertion	__ Chemical splash
__ Thermal burns	__ Pinch points	__ Poisonous plants/insects
__ Electrical	__ Cuts/abrasions	___Eye hazards/flying projectile
__ Weather conditions	__ Spills	__ Inhalation hazard
__Heights/fall> 6′	__ Overhead Electrical hazards	__ Heat/cold stress
__ Noise	__ Elevated loads	__ Water/drowning hazard
__ Explosion/fire	__ Slips, trip and falls	__ Heavy equipment
__Radiation	__ Manual lifting	__ Aerial lifts/platforms
__ Confined space entry	__Welding/cutting	__ Demolition

Other Potential Hazards (Describe):

____

CH2MHILL

PRE-TASK SAFETY PLAN

Hazard Control Measures (Check all that apply):			
PPE __ Thermal/lined __ Eye __ Dermal/hand __ Hearing __ Respiratory __ Reflective vests __ Flotation device	Protective Systems __ Sloping __ Shoring __ Trench box __ Barricades __ Competent person __ Locate buried utilities __ Daily inspections	Fire Protection __ Fire extinguishers __ Fire watch __ Non-spark tools __ Grounding/bonding __ Intrinsically safe equipment	Electrical __ Lockout/tagout __ Grounded __ Panels covered __ GFCI/extension cords __ Power tools/cord inspected
Fall Protection __ Harness/lanyards __ Adequate anchorage __ Guardrail system __ Covered opening __ Fixed barricades __ Warning system	Air Monitoring __ PID/FID __ Detector tubes __ Radiation __ Personnel sampling __ LEL/O2 __ Other	Proper Equipment __ Aerial lift/ladders/scaffolds __ Forklift/ Heavy equipment __ Backup alarms __ Hand/power tools __ Crane w/current inspection __ Proper rigging __ Operator qualified	Welding & Cutting __ Cylinders secured/capped __ Cylinders separated/upright __ Flash-back arrestors __ No cylinders in CSE __ Flame retardant clothing __ Appropriate goggles
Confined Space Entry __ Isolation __ Air monitoring __ Trained personnel __ Permit completed __ Rescue	Medical/ER __ First-aid kit __ Eye wash __ FA-CPR trained personnel __ Route to hospital	Heat/Cold Stress __ Work/rest regime __ Rest area __ Liquids available __ Monitoring __ Training	Vehicle/Traffic __ Traffic control __ Barricades __ Flags __ Signs
Permits __ Hot work __ Confined space __ Lockout/tagout __ Excavation __ Demolition __ Energized work	Demolition __ Pre-demolition survey __ Structure condition __ Isolate area/utilities __ Competent person __ Hazmat present	Inspections: __ Ladders/aerial lifts __ Lanyards/harness __ Scaffolds __ Heavy equipment __Cranes and rigging	Training: __ Hazwaste __ Construction __ Competent person __ Task-specific (THA) __ Hazcom
FieldNotes:____			

Supervisor signature:________________________________ Date:__________________

List employees who reviewed hazards identified per the checklist.

Print Name	Badge No.	Signature	SS# (Unbadged Personnel)

CH2MHILL

LOSS PREVENTION OBSERVATION

Project: ______________________	Supervisor: ______________________	Date: ______________________

Task/Operation Observed: ______________________ ______________________ ______________________	Job Title of Worker Observed: ______________________ ______________________
Background Information/comments: ______________________ ______________________ ______________________	Task Hazard Analysis completed for task (Y/N): ______________

Positive Observations/Safe Work Procedures

1.____

2.____

3.____

4.____

Questionable Activity/Unsafe Condition Observed

1.____

2.____

3.____

Observed Worker's Comment(s)

1.____

2.____

3.____

4.____

Supervisor's Corrective Actions Taken:

1.____

2.____

3.____

4.____

CH2MHILL

Loss Investigation Report Form

Employer Information

Company Name:

____

Project Name: ____ Project Number: __________________

Project Location:

____

CHIL Project? Yes ☐ No ☐

Task Location:

____

Job Assignment: ____________________________________ Business Group: ______________________

Preparer's Name: ____________________________________ Preparer's Employee Number: ______________

Near Loss Incident Specific Information

Date of Incident: _________________ Time of Incident: _________________ a.m./p.m.

Location of incident:
☐Company premises
☐Field
☐In Transit
☐Other:___________________________

Address where the incident occurred:

____

Equipment Malfunction : Yes ☐ No ☐
Activity was a Routine Task: Yes ☐ No ☐

Describe any property damage:

____

Specific activity the employee was engaged in when the incident occurred:

____

____

All equipment, materials, or chemicals the employee was using when the incident occurred:

____

____

Describe the specific incident and how it occurred:
____
____
____
____

Describe how this incident may have been prevented:
____
____
____

Contributing Factors (Describe in detail why incident occurred):
____
____
____

Date employer notified of incident: ____________________ To whom reported: ______________________________________

<u>Witness Information (First Witness)</u>
Name: ____
Employee Number (for JVII employees):
____
Address: ____
City: ____
Zip Code : ____
Phone: ____

<u>Witness Information (Second Witness)</u>
Name: ____
Employee Number (for JVII employees): ______________
Address: ____
City: ____
Zip Code: ____
Phone : ____
Additional information or comments:____
____

COMPLETE ROOT CAUSE ANALYSIS FORM

Root Cause Analysis Form

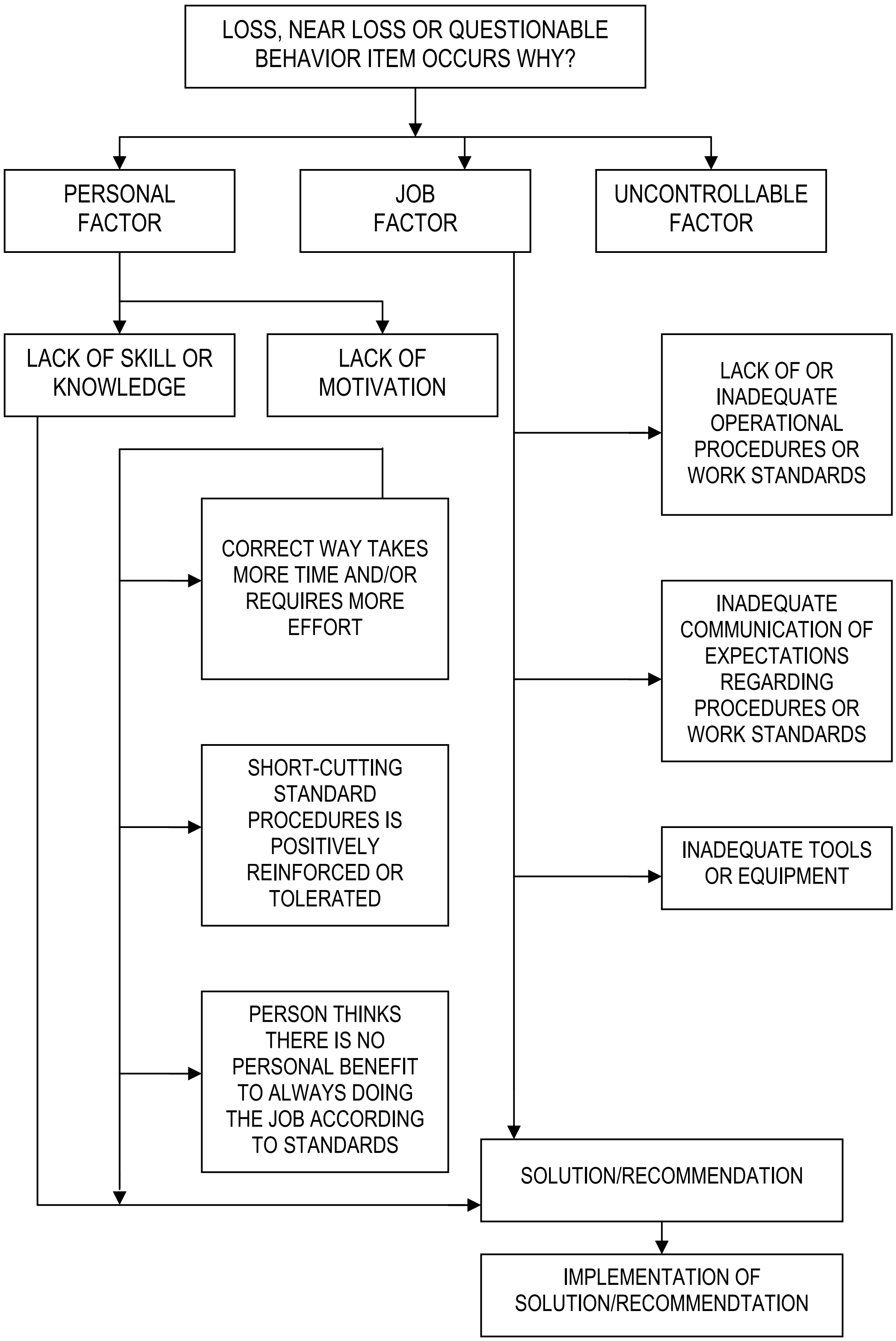
Root Cause Analysis (RCA)							
Lack of skill or knowledge Lack of or inadequate operational procedures or work standards Inadequate communication of expectations regarding procedures or work standards Inadequate tools or equipment				Correct way takes more time and/or requires more effort Short cutting standard procedures is positively reinforced or tolerated Person thinks there is no personal benefit to always doing the job according to standards Uncontrollable			
RCA #	Solution(s): How to Prevent Loss From Occurring	RC[1]	CF[2]	Corrective Action Lead	Due Date	Completion Date	Date Verified
[1] RC = Root Cause; [2] CF = Contributing Factors (check which applies)							

Investigation Team Members		
Name	Job Title	Date

Results of Solution Verification and Validation

Reviewed By		
Name	Job Title	Date

Root Cause Analysis Flow Chart



Determination of Root Cause(s)

For minor losses or near losses the information may be gathered by the supervisor or other personnel immediately following the loss. Based on the complexity of the situation, this information may be all that is necessary to enable the investigation team to analyze the loss, to determine the root cause, and to develop recommendations. More complex situations may require the investigation team to revisit the loss site or re-interview key witnesses to obtain answers to questions that may arise during the investigation process.

Photographs or videotapes of the scene and damaged equipment should be taken from all sides and from various distances. This point is especially important when the investigation team will not be able to review the loss scene.

The investigation team must use the Root Cause Analysis Flow Chart to assist in identifying the root cause(s) of a loss. Any loss may have one or more "root causes" and "contributing factors". The "root cause" is the primary or immediate cause of the incident, while a "contributing factor" is a condition or event that contributes to the incident happening, but is not the primary cause of the incident. Root causes and contributing factors that relate to the *person* involved in the loss, his or her peers, or the supervisor should be referred to as "personal factors". Causes that pertain to the *system* within which the loss or injury occurred should be referred to as "job factors".

<u>Personal Factors</u>

Lack of skill of knowledge
Correct way takes more time and/or requires more effort
Short-cutting standard procedures is positively reinforced or tolerated
Person thinks that there is no personal benefit to always doing the job according to standards

<u>Job Factors</u>

Lack of or inadequate operational procedures or work standards.
Inadequate communication of expectations regarding procedures or standards
Inadequate tools or equipment

The root cause(s) could be any one or a combination of these seven possibilities or some other "uncontrollable factor". In the vast majority of losses, the root cause is very much related to one or more of these seven factors. Uncontrollable factors should be used rarely and only after a thorough review eliminates "all" seven other factors.

Incident Report Form

Fax completed form to:
425.462.5957
JVII Seattle Office
Attention: Corporate HS&E Department

Type of Incident (Select at least one)

- ☐ Injury/Illness
- ☐ Environmental/Permit Issue
- ☐ Property Damage
- ☐ Near Miss
- ☐ Spill/Release
- ☐ Other

General Information (Complete for all incident types)

Preparer's Name: ______________________ Preparer's Employee Number: ______________
Date of Report: ______________ Date of Incident: ______________ Time of Incident: __________ am/pm

Type of Activity (Provide activity being performed that resulted in the incident)

- ☐ Asbestos Work
- ☐ Confined Space Entry
- ☐ Construction Mgmt- Haz Waste
- ☐ Construction Mgmt - Non-Haz Waste
- ☐ Demolition
- ☐ Drilling-Haz Waste
- ☐ Drilling-Non Haz Waste
- ☐ Drum Handling
- ☐ Electrical Work
- ☐ Excavation Trench-Haz Waste
- ☐ Excavation Trench-Non Haz
- ☐ Facility Walk Through
- ☐ General Office Work
- ☐ Keyboard Work
- ☐ Laboratory
- ☐ Lead Abatement
- ☐ Motor Vehicle Operation
- ☐ Moving Heavy Object
- ☐ Other (Specify) ______________
- ☐ Process Safety Management
- ☐ Tunneling
- ☐ Welding
- ☐ Wetlands Survey
- ☐ Working from Heights
- ☐ Working in Roadways
- ☐ WWTP Operation

Location of Incident (Select one)

- ☐ Company Premises (JVII Office: ______________)
- ☐ Field (Project #: __________ Project/Site Name: __________ Client: __________)
- ☐ In Transit (Traveling from: ______________ Traveling to: ______________)
- ☐ At Home

Geographic Location of Incident (Select region where the incident occurred)

- ☐ Northeast
- ☐ Southeast
- ☐ Northwest
- ☐ Southwest
- ☐ Corporate
- ☐ Canadian
- ☐ Asia Pacific
- ☐ Europe Middle East
- ☐ Latin America

If a JVII subcontractor was involved in the incident, provide their company name and phone number:
____

Describe the Incident (Provide a brief description of the incident): ______________________
____
____

Injured Employee Data (Complete for Injury/Illness incidents only)

If JVII employee injured

Employee Name: ______________________ Employee Number: ______________

If JVII Subcontractor employee injured

Employee Name: ______________ Company: ______________________

Injury Type

- ☐ Allergic Reaction
- ☐ Amputation
- ☐ Asphyxia
- ☐ Bruise/Contusion/Abrasion
- ☐ Burn (Chemical)
- ☐ Burn/Scald (Heat)
- ☐ Cancer
- ☐ Carpal Tunnel
- ☐ Concussion
- ☐ Cut/Laceration
- ☐ Dermatitis
- ☐ Dislocation
- ☐ Electric Shock
- ☐ Foreign Body in eye
- ☐ Fracture
- ☐ Freezing/Frost Bite
- ☐ Headache
- ☐ Hearing Loss
- ☐ Heat Exhaustion
- ☐ Hernia
- ☐ Infection
- ☐ Irritation to eye
- ☐ Ligament Damage
- ☐ Multiple (Specify) ____________________
- ☐ Muscle Spasms
- ☐ Other (Specify) ____________________
- ☐ Poisoning (Systemic)
- ☐ Puncture
- ☐ Radiation Effects
- ☐ Strain/Sprain
- ☐ Tendonitits
- ☐ Wrist Pain

Part of Body Injured

- ☐ Abdomen
- ☐ Ankle(s)
- ☐ Arms (Multiple)
- ☐ Back
- ☐ Blood
- ☐ Body System
- ☐ Buttocks
- ☐ Chest/Ribs
- ☐ Ear(s)
- ☐ Elbow(s)
- ☐ Eye(s)
- ☐ Face
- ☐ Finger(s)
- ☐ Foot/Feet
- ☐ Hand(s)
- ☐ Head
- ☐ Hip(s)
- ☐ Kidney
- ☐ Knee(s)
- ☐ Leg(s)
- ☐ Liver
- ☐ Lower (arms)
- ☐ Lower (legs)
- ☐ Lung
- ☐ Mind
- ☐ Multiple (Specify) ____________________
- ☐ Neck
- ☐ Nervous System
- ☐ Nose
- ☐ Other (Specify) ____________________
- ☐ Reproductive System
- ☐ Shoulder(s)
- ☐ Throat
- ☐ Toe(s)
- ☐ Upper Arm(s)
- ☐ Upper Leg(s)
- ☐ Wrist(s)

Nature of Injury

- ☐ Absorption
- ☐ Bite/Sting/Scratch
- ☐ Cardio-Vascular/Respiratory System Failure
- ☐ Caught In or Between
- ☐ Fall (From Elevation)
- ☐ Fall (Same Level)
- ☐ Ingestion
- ☐ Inhalation
- ☐ Lifting
- ☐ Mental Stress
- ☐ Motor Vehicle Accident
- ☐ Multiple (Specify) ____________________
- ☐ Other (Specify) ____________________
- ☐ Overexertion
- ☐ Repeated Motion/Pressure
- ☐ Rubbed/Abraded
- ☐ Shock
- ☐ Struck Against
- ☐ Struck By
- ☐ Work Place Violence

Initial Diagnosis/Treatment Date: ______________

Type of Treatment

- ☐ Admission to hospital/medical facility
- ☐ Application of bandages
- ☐ Cold/Heat Compression/Multiple Treatment
- ☐ Cold/Heat Compression/One Treatment
- ☐ First Degree Burn Treatment
- ☐ Heat Therapy/Multiple treatment
- ☐ Multiple (Specify) ____
- ☐ Heat Therapy/One Treatment
- ☐ Non-Prescriptive medicine
- ☐ None
- ☐ Observation
- ☐ Other (Specify) ____
- ☐ Prescription- Multiple dose
- ☐ Prescription- Single dose
- ☐ Removal of foreign bodies
- ☐ Skin Removal
- ☐ Soaking therapy- Multiple Treatment
- ☐ Soaking Therapy- One Treatment
- ☐ Stitches/Sutures
- ☐ Tetanus
- ☐ Treatment for infection
- ☐ Treatment of 2nd /3rd degree burns
- ☐ Use of Antiseptics – multiple treatment
- ☐ Use of Antiseptics – single treatment
- ☐ Whirlpool bath therapy/multiple treatment
- ☐ Whirlpool therapy/single treatment
- ☐ X-rays negative
- ☐ X-rays positive/treatment of fracture

Number of days doctor required employee to be off work: _________
Number of days doctor restricted employee's work activity: _________
Equipment Malfunction : Yes ☐ No ☐ Activity was a Routine Task: Yes ☐ No ☐
Describe how you may have prevented this injury: ____

____

Physician Information
Name: ______________________________
Address: ______________________________
City: ______________________________
Zip Code: ______________________________
Phone: ______________________________

Hospital Information
Name: ______________________________
Address: ______________________________
City: ______________________________
Zip Code: ______________________________
Phone: ______________________________

Property Damage (Complete for Property Damage incidents only)

Property Damaged: ______________________________ Property Owner: __________________
Damage Description: ____
Estimated Amount: $ ________________

Spill or Release (Complete for Spill/Release incidents only)

Substance (attach MSDS): ______________________________ Estimated Quantity: ______________
Facility Name, Address, Phone No.: ____
Did the spill/release move off the property where work was performed?: ____________________
Spill/Release From: __________________________ Spill/Release To: ________________________

Environmental/Permit Issue (Complete for Environmental/Permit Issue incidents only)

Describe Environmental or Permit Issue: ____
Permit Type: ____
Permitted Level or Criteria (e.g., discharge limit): ____________________________________
Permit Name and Number (e.g., NPDES No. ST1234): ____________________________________
Substance and Estimated Quantity: ____
Duration of Permit Exceedence: ____

Verbal Notification (Complete for all incident types)(Provide names, dates and times)

JVII Personnel Notified: ____
Client Notified: ____

Witnesses (Complete for all incident types)

Witness Information (First Witness)
Name: ______________________________
Employee Number (CH2M HILL):________________
Address: ______________________________
City: ______________________________
Zip Code:______________________________
Phone: ______________________________

Witness Information (Second Witness)
Name: ______________________________
Employee Number (CH2M HILL: ______________
Address: ______________________________
City: ______________________________
Zip Code:______________________________
Phone :______________________________

Additional Comments:

____

____

NEAR LOSS INVESTIGATION FORM

Employer Information

Company Name: ____

Project Name: ______________________________ Project Number: ____________

Project Location: ____

CHIL Project? Yes ☐ No ☐

Task Location: ____

Job Assignment: ______________________________ Business Group: ______________

Preparer's Name: ______________________________ Preparer's Employee Number: __________

Near Loss Incident Specific Information

Date of Incident: ____________ Time of Incident: ____________ a.m./p.m.

Location of incident:
☐Company premises ☐Field ☐In Transit ☐Other:______________

Address where the incident occurred: ______________________________________

Equipment Malfunction : Yes ☐ No ☐ Activity was a Routine Task: Yes ☐ No ☐

Describe any property damage: ______________________________________

Specific activity the employee was engaged in when the incident occurred:
____
____

All equipment, materials, or chemicals the employee was using when the incident occurred:
____
____

Describe the specific incident and how it occurred:
____
____
____

Describe how this incident may have been prevented:
____
____
____

Contributing Factors (Describe in detail why incident occurred):
____
____
____

Date employer notified of incident: ____________ To whom reported: ______________________

NEAR LOSS INVESTIGATION FORM

Witness Information (First Witness)

Name: ____
Employee Number (for CH2M HILL employees):__________
Address: ____
City: ____
Zip Code : ____
Phone: ____

Witness Information (Second Witness)

Name: ____
Employee Number (for CH2M HILL employees): _________
Address: ____
City: ____
Zip Code: ____
Phone : ____

Additional information or
comments:____
____

Attachment 7

Applicable Material Safety Data Sheets
(available onsite)

Attachment 8

Subcontractor H&S Plans/Procedures

Appendix F

EOS® Quantity Calculations

EOS Remediation, Inc.

1101 Nowell Road, Raleigh, NC 27607
(919) 873-2204● Fax (919) 873-1074
www.eosremediation.com

Emulsified Oil Amendment Calculations

The following text provided below was generally taken from a soon to be published *Protocol for In Situ Bioremediation of Chlorinated Solvents Using Edible Oil* that is currently being prepared by the **EOS®** development team.

There are several important issues to consider in determining how much **EOS®** to inject into the subsurface:

- The objectives of the remediation effort and the design configuration best suited to meet the project objectives;
- Consumption of **EOS®** during biodegradation of the contaminants including biodegradation of competing electron acceptors (e.g., oxygen, nitrate, sulfate);
- Downgradient release of dissolved organic carbon and methane; and
- Entrapment of **EOS®** by aquifer material.

Oil Consumption During Contaminant Biodegradation

The amount of **EOS®** required to support contaminant biodegradation is a function of: (a) treatment zone dimensions; (b) site hydrogeology; (c) the system design life; (d) the amount of electron acceptors entering the treatment zone (both contaminants and naturally occurring electron acceptors); and (e) additional hydrogen demands and release of dissolved organic carbon to the downgradient aquifer. The following subsections outline the various calculations and potential safety factors that should be considered when estimating the amount of **EOS®** required using site-specific data and design criteria.

Treatment Zone Dimensions

For a permeable reactive barrier design, the length and depth of the barrier must first be determined based on the site characteristics. The area of the barrier is then used along with the groundwater flow velocity, contaminant concentrations, and competing electron acceptor concentrations to calculate the anticipated mass flux of contaminants and competing electron acceptors through the barrier. The barrier will be designed to provide sufficient substrate for a given time period (e.g, 5 to 10 years) taking into consideration the mass flux of contaminants and competing electron acceptors and accounting for losses from the barrier due to methane production and release of organic and inorganic carbon.

A source area treatment is designed in a similar manner. After determining the length, width, and thickness of the area targeted for treatment, the amount of substrate can be determined based on the treatment volume, contaminant concentrations, and competing electron acceptor concentrations. The potential mass flux of contaminants and competing electron acceptors into the treatment area can also be calculated using the upgradient concentrations, width and depth of the treatment area, and the groundwater flow velocity. The goal of the treatment is to provide sufficient substrate to destroy the contaminant mass within the treatment area and reduce any potential mass flux of contaminants into the area during the effective life of the treatment.

Site Hydrogeology

For a barrier design, the volume of water to be treated can be calculated using the dimensions of the barrier, the groundwater flow, and the design life. Barriers are typically placed across a plume perpendicular to the direction of groundwater flow and are usually somewhat wider than the plume to minimize the potential for contaminated groundwater to flow around the barrier without passing through the treatment zone.

The width of the proposed barrier can be entered into the barrier design spreadsheet. These inputs are used to calculate the cross-sectional area of the barrier. Site-specific hydrogeologic properties (effective porosity, hydraulic conductivity, and hydraulic gradient) are then entered and are used to calculate the groundwater seepage velocity through the barrier by applying Darcy's Law. The spreadsheet uses the cross-sectional area of the barrier and the groundwater seepage velocity to determine the groundwater flux through the barrier (gallons/year). The treatment volume is then calculated using the design life (e.g., 5 to 10 years).

For a source area treatment, the volume of water to be treated is determined based on the volume within the treatment zone and the flow into the treatment zone during the treatment period. The treatment area dimensions are entered into the spreadsheet along with the effective porosity. The volume of water within the treatment zone is simply obtained by multiplying the length, width, depth, and effective porosity of the treatment area. The flow into the treatment zone is determined using the same procedure as for the barrier above to calculate the groundwater flux through the upgradient cross-sectional area of the treatment cell based on site-specific groundwater flow inputs. The groundwater flux (gallons/year or L/year) is then multiplied by the design life (years) and this value is added to the volume within the treatment cell to obtain the total treatment volume (gallons or liters).

System Design Life

When selecting a design life, one should be aware that the spreadsheet assumes the barrier or source area treatment will operate at 100% efficiency until the day when the organic substrate runs out. On that day, the treatment efficiency is assumed to drop to zero. However in practice, treatment efficiency will begin to decline as substrate is depleted from the more permeable or contaminated zones. Consequently, one should include an appropriate factor of safety when selecting the design life. In some barrier projects, a ten-year design life has been used with the assumption that additional edible oil may need to be injected after three to five years.

Estimating the required design life for a source area treatment is more difficult. Laboratory studies and field pilot tests have demonstrated that edible oil addition can stimulate rapid biodegradation of contaminants in the more mobile zones with contaminants degraded to low levels in 6 to 12 months. However, mass transfer limitations may greatly reduce the rate that DNAPLs and contaminants in low permeability zones are degraded. If residual edible oils are present, aqueous phase contaminants will be degraded as they diffuse out into the more mobile portions of the aquifer. However, once the edible oil is depleted, aqueous phase contaminants may be released to the downgradient aquifer. For heavily contaminated source areas, a five-year **EOS®** supply should be provided as a minimum with the expectation that additional **EOS®** may need to be injected at some time in the future.

Hydrogen Demand

EOS® ferments in the subsurface generating hydrogen and acetate. The hydrogen and acetate is then used to support reductive dechlorination. However, hydrogen and acetate may also be consumed during biodegradation of naturally occurring electron acceptors including oxygen, nitrate, sulfate, ferric iron, and manganese. As a consequence, designers must consider both the amount of contaminant to be degraded and the background electron acceptor load.

The amount of **EOS®** required to reduce a mass of dissolved contaminants and/or electron acceptors can be determined by calculating the stoichiometric hydrogen demand of the dissolved contaminants/electron acceptors. First, the contaminant and electron acceptor mass to be degraded is calculated by multiplying the average concentrations by the total groundwater treatment volume. The stoichiometric hydrogen demand required to reduce the contaminant mass can then be calculated by determining the amount of molecular hydrogen (H_2) required for complete reduction of each contaminant or background electron acceptor. The stoichiometric demand is the mass ratio of the contaminant to hydrogen (weight contaminant/weight H_2) and is based upon balanced chemical reduction equations.

For example, TCE is completely reduced to ethene according to the following equation:

$$C_2HCl_3 + 3H_2 \rightarrow C_2H_4 + 3H^+ + 3Cl^-$$

Since it takes 3 moles of hydrogen (molecular weight = 2.0158) to reduce 1 mole of TCE (molecular weight = 131.389) to ethene, the stoichiometric hydrogen demand is 131.389 divided by 6.047 (3 x 2.0158) or 21.73 (wt/wt H_2). Therefore, 21.73 grams of TCE is degraded per gram of hydrogen. Similar calculations can be done for each contaminant and electron acceptor to determine the stochiometric hydrogen demand.

For each contaminant or electron acceptor, the mass is divided by the stoichiometric hydrogen demand to determine the mass of hydrogen required to reduce the contaminant mass. The **EOS®** demand is determined by dividing the calculated hydrogen demand for degradation of contaminants and electron acceptors by the amount of hydrogen produced from **EOS®**.

Additional Hydrogen Demands and Organic Carbon Released Downgradient

In addition to the contaminants and electron acceptors entering the treatment zone, hydrogen can be consumed during reduction of iron oxides and manganese oxides present in the sediment, methane production, and release of dissolved organic carbon (DOC). The best approach for estimating the iron and manganese demand is to directly measure the amount of iron and manganese oxides in the aquifer material. Unfortunately, these data are not commonly available. An alternative approach is to calculate the iron and manganese demand based on the amount of dissolved iron and manganese released to the downgradient aquifer. This approach may somewhat under estimate the iron and manganese demand, but should be a reasonable approximation in most cases. In previous field studies, dissolved iron concentrations released from edible oil barriers typically have varied between 10 and 100 mg/L with somewhat lower levels of dissolved manganese.

Hydrogen and acetate that are not consumed by reductive dechlorination or electron acceptor reduction will be fermented to methane or released to the downgradient aquifer. As a consequence, additional substrate must be injected to account for any methane production and DOC released. In previous **EOS®** projects, methane concentrations downgradient from the treatment zone have varied between 5 and 20 mg/L. Immediately after oil injection, DOC concentrations in groundwater may exceed 500 mg/L. However, DOC concentrations decline with time reaching quasi-steady-state levels of 20 to 50 mg/L. Consequently, 60 to 100 mg/L appears to be a reasonable range for the long-term average concentration released.

The barrier and source treatment design spreadsheets estimate the amount of substrate use for methane production and the amount of carbon lost from the barrier over time. These values are estimated by entering estimated methane concentrations and DOC concentrations in the spreadsheet. The total amount of **EOS®** required to support contaminant biodegradation is then calculated.

Oil Entrapment by Aquifer Material

For effective treatment, NAPL edible oils and edible oil emulsions must be distributed throughout the treatment zone. However as oils migrate through the aquifer pore spaces, a significant amount is retained. For NAPLs, the oil is trapped in the aquifer pores as large globules, typically retaining 1 to 20 lb of oil per cubic foot of treated material. For **EOS®**, the small oil droplets coat the sediment surfaces, typically retaining between 0.1 to 0.5 lb of oil per cubic foot of treated material. The amount of oil required to treat an aquifer is determined by multiplying the treatment zone volume by the oil retention in lb/ft^3.

Summary – How much oil do you need?

To determine the amount of oil required, calculate the **EOS®** requirement for biodegradation, entrapment by the aquifer material and for sorption. The oil required will be the larger of the two values.

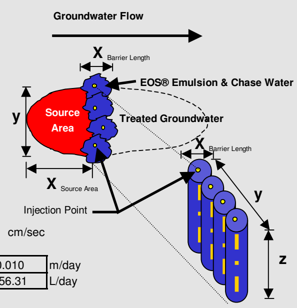
Emulsified Edible Oil Design Software
for EOS® 598 B42
Beta Version 1.2 Rev. Date Aug. 31, 2005
www.eosremediation.com

EOS Remediation, Inc.

Site Name:	JV II TO 2 No. 144 for services at Study Area 17 - Naval Training Center
Location:	Orlando, Florida
Project No.:	N62467-03-D-0260 LOWER ZONE (C)

Section A: Treatment Area Dimensions

Length of treatment area parallel to groundwater flow, "x"	50	ft	15.2	m
Width of treatment area perpendicular to groundwater flow, "y"	50	ft	15.2	m
Minimum depth to contamination	30	ft	9.1	m
Maximum depth of contamination	50	ft	15.2	m
Treatment thickness, "z"	20	ft	6.1	m
Treatment zone cross-sectional area = y * z	1,000	ft^2	92.9	m^2



Section B: Groundwater Flow Rate / Site Data

Soil Characteristics

Nominal Soil Type (enter clay, silt, silty sand, or sand)	silty sand			

Hydraulic Characteristics

Total Porosity (accept default or enter *n*)	0.28	(decimal)		
Effective Porosity (accept default or enter n_e)	0.17	(decimal)		
Hydraulic Conductivity (accept default or enter *K*)	6.9	ft/day	2.4E-03	cm/sec
Hydraulic Gradient (accept default or enter *i*)	0.0008	ft/ft		
Non-reactive Transport Velocity (V_x) = K * i / n_e	0.03	ft/day	0.010	m/day
Groundwater flowrate through treatment zone (Q)	41.29	gallons/day	156.31	L/day

Section C: Calculated Contact Length (x) = C_t * V_x

Contact time (C_t) between oil and contaminants (accept default or enter C_t)	180	typical values 60 to 180 days, see comment	
Calculated Contact Length (x) = Ct * V_x	5.8	ft	

Treatment zone volume	50,000	ft^3	1,416	m^2
Treatment zone groundwater volume (volume * effective porosity)	63,580	gallons	240,693	L

Section D: Design Lifespan For One Application

	5	year(s)	typical values 5 to 10 years	
Estimated total groundwater volume treated over design life	138,934	gallons	525,957	L

Section E: Electron Acceptors

Inputs	Typical Value	GW Conc. (mg/L)	MW (g/mole)	e^- equiv./ mole	Stoichmetry *Contaminant/H_2* *(wt/wt H_2)*	Hydrogen Demand *(g H_2)*
Dissolved Oxygen (DO)	0 to 8	5	32.0	4	7.94	331.3325311
Nitrate Nitrogen (NO_3^- - N)	1 to 10	10	62.0	5	12.30	427.4760299
Sulfate (SO_4^{2-})	10 to 500	250	96.1	8	11.91	11037.38111
Tetrachloroethene (PCE), C_2Cl_4		0.01	165.8	8	20.57	0.255731476
Trichloroethene (TCE), C_2HCl_3		15	131.4	6	21.73	363.1212019
cis-1,2-dichloroethene (c-DCE), $C_2H_2Cl_2$		0.01	96.9	4	24.05	0.218729685
Vinyl Chloride (VC), C_2H_3Cl		0.01	62.5	2	31.00	0.169639423
Carbon tetrachloride, CCl_4			153.8	8	19.08	
Chloroform, $CHCl_3$			119.4	6	19.74	
sym-tetrachloroethane, $C_2H_2Cl_4$			167.8	8	20.82	
1,1,1-Trichloroethane (TCA), CH_3CCl_3			133.4	6	22.06	
1,1-Dichloroethane (DCA), CH_3CHCl_2			99.0	4	24.55	
Chloroethane, C_2H_5Cl			64.9	2	32.18	
Perchlorate, ClO_4^-			99.4	8	12.33	
Hexavalent Chromium, Cr[VI]			52.0	3	17.20	
User added						
User added						
User added						

Section F: Additional Hydrogen Demand and Carbon Losses

Generation (Potential Amount Formed)	Typical Value	GW Conc. (mg/L)	MW (g/mole)	e^- equiv./ mole	Stoichmetry *Contaminant/H_2* *(wt/wt H_2)*	Hydrogen Demand *(g H_2)*	DOC Released *(moles)*
Estimated Amount of Fe^{2+} Formed	10 to 100	100	55.8	1	55.41	949.2562803	
Estimated Amount of Manganese (Mn^{2+}) Formed		5	54.9	2	27.25	96.49280457	
Estimated Amount of CH_4 Formed	5 to 20	10	16.0	8	1.99	2643.52247	
Target Amount of DOC to Release	60 to 100	100	12.0				4378.96

Note:
Calculations assume:
1.) all reactions go to completion during passage through emulsified edible oil treated zone; and,
2.) perfect reaction stoichiometry.

EOS® Requirement Calculations Based on Hydrogen Demand and Carbon Losses

Stoichiometric Hydrogen Demand	35	pounds
DOC Released	150	pounds

EOS® Requirement Based on Hydrogen Demand and Carbon Loss

2 drums

Substrate Requirement Calculations Based on Adsorptive Capacity of Soil

Soil Characteristics

Density of soil (accept default or enter site specific value)	125	lbs / ft3
Effective Thickness (typically less than 40%)	0.30	
Weight of sediment to be treated	1,875,000	lbs
Adsorptive Capacity of Soil (accept default or enter site specific value)	0.002	lbs EOS® / lbs soil

Aquifer "Sorption" Capacity[1]

- Fine sand with some clay 0.001 to 0.002 lbs EOS® / lbs soil
- Sand with higher silt/clay content 0..002 to 0.004 lbs EOS® / lbs soil

[1]Default values provided based on laboratory studies completed by NCSU

EOS® Requirement Based on Adsorptive Capacity of Soil

9 drums

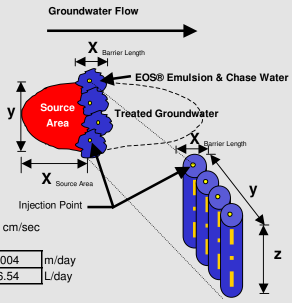
Suggested Quantity of EOS® for Your Project 9 drums

EOS Remediation, Inc.

Emulsified Edible Oil Design Software
for EOS® 598 B42

Beta Version 1.2 Rev. Date Aug. 31, 2005
www.eosremediation.com

Site Name:	JV II TO 2 No. 144 for services at Study Area 17 - Naval Training Center
Location:	Orlando, Florida
Project No.:	N62467-03-D-0260 UPPER ZONE (A/B)



Section A: Treatment Area Dimensions

Length of treatment area parallel to groundwater flow, "x"	50	ft	15.2	m
Width of treatment area perpendicular to groundwater flow, "y"	50	ft	15.2	m
Minimum depth to contamination	5	ft	1.5	m
Maximum depth of contamination	25	ft	7.6	m
Treatment thickness, "z"	20	ft	6.1	m
Treatment zone cross-sectional area = y * z	1,000	ft^2	92.9	m^2

Section B: Groundwater Flow Rate / Site Data

Soil Characteristics				
Nominal Soil Type (enter clay, silt, silty sand, or sand)	silty sand			
Hydraulic Characteristics				
Total Porosity (accept default or enter *n*)	0.28	(decimal)		
Effective Porosity (accept default or enter n_e)	0.17	(decimal)		
Hydraulic Conductivity (accept default or enter *K*)	4.7	ft/day	1.7E-03	cm/sec
Hydraulic Gradient (accept default or enter *i*)	0.0005	ft/ft		
Non-reactive Transport Velocity (V_x) = K * i / n_e	0.01	ft/day	0.004	m/day
Groundwater flowrate through treatment zone (Q)	17.58	gallons/day	66.54	L/day

Section C: Calculated Contact Length (x) = C_t * V_x

Contact time (C_t) between oil and contaminants (accept default or enter C_t)		180	typical values 60 to 180 days, see comment	
Calculated Contact Length (x) = Ct * V_x	**Suggested Minimum**	5.0	ft	
Treatment zone volume	50,000	ft^3	1,416	m^2
Treatment zone groundwater volume (volume * effective porosity)	63,580	gallons	240,693	L

Section D: Design Lifespan For One Application

	5	year(s)	typical values 5 to 10 years	
Estimated total groundwater volume treated over design life	95,660	gallons	362,137	L

Section E: Electron Acceptors

Inputs	Typical Value	GW Conc. (mg/L)	MW (g/mole)	e^- equiv./ mole	Stoichmetry *Contaminant/H_2* *(wt/wt H_2)*	Hydrogen Demand *(g H_2)*
Dissolved Oxygen (DO)	0 to 8	5	32.0	4	7.94	228.1322767
Nitrate Nitrogen (NO_3^- - N)	1 to 10	10	62.0	5	12.30	294.3299277
Sulfate (SO_4^{2-})	10 to 500	250	96.1	8	11.91	7599.564318
Tetrachloroethene (PCE), C_2Cl_4		0.01	165.8	8	20.57	0.176078707
Trichloroethene (TCE), C_2HCl_3		15	131.4	6	21.73	250.0197195
cis-1,2-dichloroethene (c-DCE), $C_2H_2Cl_2$		0.01	96.9	4	24.05	0.150601876
Vinyl Chloride (VC), C_2H_3Cl		0.01	62.5	2	31.00	0.116801775
Carbon tetrachloride, CCl_4			153.8	8	19.08	
Chloroform, $CHCl_3$			119.4	6	19.74	
sym-tetrachloroethane, $C_2H_2Cl_4$			167.8	8	20.82	
1,1,1-Trichloroethane (TCA), CH_3CCl_3			133.4	6	22.06	
1,1-Dichloroethane (DCA), CH_2CHCl_2			99.0	4	24.55	
Chloroethane, C_2H_5Cl			64.9	2	32.18	
Perchlorate, ClO_4^-			99.4	8	12.33	
Hexavalent Chromium, Cr[VI]			52.0	3	17.20	
User added						
User added						
User added						

Section F: Additional Hydrogen Demand and Carbon Losses

Generation (Potential Amount Formed)	Typical Value	GW Conc. (mg/L)	MW (g/mole)	e^- equiv./ mole	Stoichmetry *Contaminant/H_2* *(wt/wt H_2)*	Hydrogen Demand *(g H_2)*	DOC Released *(moles)*
Estimated Amount of $Fe2^+$ Formed	10 to 100	50	55.8	1	55.41	326.7955544	
Estimated Amount of Manganese (Mn^{2+}) Formed		5	54.9	2	27.25	66.43815842	
Estimated Amount of CH_4 Formed	5 to 20	10	16.0	8	1.99	1820.143641	
Target Amount of DOC to Release	60 to 100	100	12.0				3015.05

Note:
Calculations assume:
1.) all reactions go to completion during passage through emulsified edible oil treated zone; and,
2.) perfect reaction stoichiometry.

EOS® Requirement Calculations Based on Hydrogen Demand and Carbon Losses

Stoichiometric Hydrogen Demand	23	pounds
DOC Released	104	pounds

EOS® Requirement Based on Hydrogen Demand and Carbon Loss
1 drums

Substrate Requirement Calculations Based on Adsorptive Capacity of Soil

Soil Characteristics

Density of soil (accept default or enter site specific value)	125	lbs / ft3
Effective Thickness (typically less than 40%)	0.30	
Weight of sediment to be treated	1,875,000	lbs
Adsorptive Capacity of Soil (accept default or enter site specific value)	0.002	lbs EOS® / lbs soil

Aquifer "Sorption" Capacity[1]
- Fine sand with some clay 0.001 to 0.002 lbs EOS® / lbs soil
- Sand with higher silt/clay content 0..002 to 0.004 lbs EOS® / lbs soil

[1]Default values provided based on laboratory studies completed by NCSU

EOS® Requirement Based on Adsorptive Capacity of Soil
9 drums

Suggested Quantity of EOS® for Your Project 9 drums

Appendix G

Optimization Study Report for SA 17, NTC Orlando

Optimization Report for Study Area 17, Former Naval Training Center, Orlando, Florida

PREPARED FOR:	Barbara Nwokike/NAVFAC EFD SOUTH Steve McCoy/TtNUS David Grabka/FDEP Greg Fraley/EPA
COPIES:	Mike Singletary/ NAVFAC EFD SOUTH Paul Cotter/EFA SOUTHEAST Steve Tsangaris/CH2M HILL Scott Smith/CH2M HILL Sam Naik/CH2M HILL
PREPARED BY:	Paul Favara/CH2M HILL
DATE:	March 17, 2005

Introduction

The Department of the Navy's (DON) environmental restoration mission is to protect human health and the environment while supporting the defense mission by ensuring continued use of lands necessary for military operations at active Navy sites (DON, 2003). This mission is supported, in part, by an ongoing effort to improve the performance and cost effectiveness of the Installation Restoration (IR) program. This Optimization Report supports this ongoing effort by incorporating remedy optimization concepts in the remedy selection phase of the Environmental Restoration program.

This work is being performed under the Remedial Action Contract No. N62467-01-D-0331, Contract Task Order (CTO) 0004 at the former Naval Training Center (NTC) Orlando, Florida

This report provides the following information necessary to optimize the remedy at Study Area (SA) 17:

- Background of the site and latest understanding of site conditions
- Uncertainty in site understanding
- Areas that require treatment
- Goals of the remedial action, by specifying remedial action objectives and performance objectives
- Alternatives that can be used to remediate the site
- Recommendation of the alternative to implement at SA 17

- Other recommendations necessary to address the uncertainties presented in this Optimization Report

The report is organized into nine sections:

- Background
- Conceptual Site Model
- Remedial Action Objectives
- Target Treatment Zone(s)
- Treatment Technology Evaluation
- Performance Objectives
- Optimization and Exit Strategies
- Recommendations
- References

Tables and figures are provided at the end of the text, followed by Attachments.

This report was prepared using *Guidance for Optimizing Remedy Evaluation, Selection, and Design* (NAVFAC, 2004), *Guidance for Optimizing Remedial Action Operation (RAO)* (NAVFAC, 2001), conclusions from the November 23, 2004, Technical Review Meeting, as well as previous findings and conclusions for SA 17.

Background

SA 17 is located at NTC Orlando, a former Navy facility located in the city of Orlando, Florida. SA 17 occupies approximately 25 acres in the central part of the McCoy Annex. The site includes Buildings 7178, 7191, and 7193, and the adjacent area that formerly served as the Defense Property Disposal Office (DPDO) complex for the McCoy Annex.

In order to identify and evaluate areas where environmental media may have been adversely affected by past site activities, an initial site screening investigation was performed in 1995 by ABB Environmental Services, Inc. (ABB). Findings from that investigation indicated exceedance of screening criteria for polynuclear aromatic hydrocarbons (PAHs) in soil and chlorinated volatile organic compounds (CVOCs) in groundwater. Subsequently, the Orlando Partnering Team (OPT) requested that Harding Lawson Associates (HLA) perform supplemental screening investigations to evaluate and characterize the CVOC contamination at the site.

Results of the supplemental screening investigation indicated that the suspected source of CVOC-contaminated groundwater at the site is related to operations at the former motor pool area. The highest total CVOC concentration detected during the investigation was 65,000 micrograms per liter (μg/L).

CH2M HILL Phase I and II Confirmatory Sampling

The OPT requested that CH2M HILL perform an Interim Remedial Action (IRA), consisting of confirming site conditions, developing an IRA approach, and implementing an appropriate IRA. CH2M HILL collected groundwater data and the results of those Phase I and II confirmatory sampling activities are documented in the technical memorandum entitled *Phase I and II Data Report for Study Area 17, NTC Orlando* (CH2M HILL, 2000).

The objectives of the Phase I and II site characterization were to complete the delineation (nature and extent) of the contamination and obtain additional information on site-specific geologic conditions, especially as they relate to the potential implementation of specific interim remedial actions. Site characterization activities using a direct-push technology (DPT) rig were conducted at the site from March 21 to April 7, 2000. Following the DPT sampling activities, additional monitoring wells were installed at the SA 17 site. During the Phase II site characterization, media and groundwater samples from contaminated areas at the site were collected and provided to potential IRA subcontractors for bench scale treatability testing. The results of the Phase I and II site characterization activities are documented in the technical memorandum entitled *Phase I and II Data Report for Study Area 17, NTC Orlando* (CH2M HILL, 2000).

CVOCs adversely impacted the groundwater throughout the surficial aquifer and in isolated areas within the upper part of the intermediate aquifer of the Hawthorn Group sediments. Given the contaminant distribution pattern, the plume appeared to have originated from two release points at the surface located in the western and central parts of the former motor pool area. In the western source area, compounds detected at the highest concentrations were cis-1,2-dichloroethene (cis-1,2-DCE) and vinyl chloride, with a maximum concentration of 400 µg/L. In the eastern source area, trichloroethene (TCE) was the predominant compound detected, with a maximum concentration of 65,000 µg/L. The highest contaminant concentrations were detected at the water table interface in the source areas and along the upper surface of a silty sand layer that is located between 15 and 25 feet below land surface (bls). This layer and another somewhat deeper layer of silty sand act as leaky aquitards that divide the surficial aquifer into three units—shallow, intermediate, and deep.

As a result of the Phase I and II site characterization, the interpreted areal extent of the CVOC plume was defined as extending from the water table interface of both source areas for a distance of approximately 50 to 100 feet in the direction of groundwater flow (east-southeast). In the intermediate unit of the surficial aquifer, the plume extends approximately 250 feet downgradient, and in the deep unit of the aquifer, the plume extends approximately 300 feet from the source areas.

IRA Using In Situ Chemical Oxidation

Subsequent to completion of the Phase I and II site characterization activities, CH2M HILL issued a Request for Bid to implement an IRA consisting of in situ chemical oxidation (ISCO) using Fenton's Chemistry for source control/reduction of the chlorinated solvent plume at the SA 17. CH2M HILL contracted with Geo-Cleanse International (GCI) to implement the IRA. ISCO injections at SA 17 were divided into two distinct phases. Phase I consisted of two injection events conducted from November 2000 through January 2001. Phase II consisted of three injection events conducted from March 2002 through September 2002. A summary of the field activities and findings from each phase are provided in the *Construction Documentation Report for the Interim Remedial Action at SA 17* (CH2M HILL, 2003).

The remedial goal of the IRA was to reduce the contaminant source area mass and volume to the extent possible. A total CVOC concentration of 500 µg/L was established as the treatment objective. Total CVOC concentration is a summation of TCE, cis-1,2-DCE; 1,1-dichloroethene (1,1-DCE), 1,1-dichloroethane (1,1-DCA), and vinyl chloride.

Monitoring well data were used to evaluate the effectiveness of the ISCO IRA at SA 17. The data analysis showed dissolved phase concentration reductions of 89 percent TCE and 87 percent CVOCs were achieved as a result of the ISCO IRA conducted at SA 17, as measured in 2003.

Post-IRA Site Evaluation

Based on the data generated during two post-treatment sampling events completed in January and June 2003, concentrations of TCE greater than 1 percent of the maximum solubility in water have been detected in two deep injectors (D-25 and D-33) and two monitoring wells (OLD-17-23A and OLD-17-24B). The maximum solubility of TCE in water is approximately 1,100 milligrams per liter (mg/L). Concentrations greater than 1 percent of solubility (in the case of TCE, this concentration is 11,000 µg/L) are considered a likely indicator of the presence of a dense non-aqueous phase liquid (DNAPL) source area near the monitored location. As a result of these elevated TCE concentrations, CH2M HILL recommended a focused investigation to better characterize the localized areas of elevated concentration.

The investigation included a Membrane Interface Probe (MIP) investigation and collection of discrete soil and groundwater samples. As a result of this investigation, the location and depths of the most contaminated soil and groundwater were identified at SA 17. The findings from this investigation were reported in *CVOC Source Area Investigation and Focused Feasibility Study* (CH2M HILL, 2004).

Most of the historical site investigations focused on investigation and remediation of the source area. In an effort to address SA 17 as a whole, CH2M HILL recommended a more comprehensive investigation of the site to provide information necessary for the development of the overall closure strategy. In August 2004, CH2M HILL completed a comprehensive sampling effort that involved the collection of groundwater samples for CVOC and MNA analysis. The results of this investigation, as reported in *Summary of Data Collection Activities, Study Area SA 17, Former Naval Training Center Orlando* (CH2M HILL, 2005), concluded that high levels of contaminants are present in the source area and that natural attenuation activity is observed in the downgradient portions of the plume.

In addition to the above reports and findings, an additional technical effort was performed to support this optimization study. Two models were evaluated for the purposes of estimating the Time of Remediation (TOR) and Time of Stabilization (TOS) of the groundwater plume. The TOR estimates the timeframe required to achieve a pre-determined cleanup level at the source of contamination. TOS refers to the time required to achieve a pre-determined compliance or target concentration at a fixed distance downgradient of the source area.

The two different models were used to support TOR estimates; results are discussed in Attachment A. Overall, the results of the TOR efforts concluded that only removal of a substantial percentage of the mass from the source area will result in any noticeable reduction of TOR. These findings are discussed in further detail in Attachment A and the following sections.

Conceptual Site Model

Figures 1 and 2 present a conceptual site model (CSM) in plan and profile view. Figure 3 presents a geologic cross-section of the site. Based on historical information and current understanding of the site, the following information about the CSM for SA 17 can be concluded:

- Contaminant Source and Release Information
  - TCE appears to have entered the ground at a surface location and migrating began vertically downward.
  - TCE continued to move downward until it encountered a horizontal zone of lesser permeability (at approximately 10 to 15 feet and again at approximately 25 to 30 feet).
  - When TCE encountered lithology of lesser permeability, it would accumulate and spread out over the feature and also fill the pore space of the less permeable material.
  - In some instances, the horizontal feature may have been thin, or discontinuous, and allowed a vertical migration pathway to be established that allowed TCE to continue its downward vertical migration.
  - In other instances, the TCE encountered a horizontal feature that was able to further retard downward migration of contaminants.
  - Dense non-aqueous phase liquid (DNAPL) was not observed in any of the sampling efforts but is suspected to be present based on the 1 percent rule of thumb (that is, TCE concentrations exceed 1 percent of its solubility in water [11,000 µg/L]), most likely present as ganglia representing small volumes of liquid in pore space.
- Geologic and Hydrologic Information
  - The upper 30 feet of sediments consists primarily of fine sand with the exception of two thin (approximately 5- to 10-feet) discontinuous layers of silty sand. The upper layer of the silty sand lies at about 10 to 15 feet bls and appears to dip to the east and northeast.
  - The lower layer of silty sand lies at about 25 to 30 feet bls and appears to be continuous across the site.
  - Below the lower layer of silty sand is an interval of fine- to coarse-grained sand that extends from about 30 to 50 feet bls. Because of its green coloration, this layer marks the upper part of the Hawthorn Group of sediments. This interval is underlain by another silty-sand layer that extends from 50 to 55 feet bls, which is in turn underlain by approximately 10 feet of sandy, silty clay. This clay is considered to be the bottom of the surficial aquifer and is underlain by fine- to coarse-grained sand of the Hawthorn Group sediments.
  - Water lies at approximately 6 feet bls across the site, with a variation of 2 feet.

- The surficial aquifer extends to a depth of about 55 feet and the uppermost Hawthorn clay layer.
- Groundwater elevation data indicate radial flow away from a groundwater high located across the central portion of SA 17.
- The location of a buried water-supply line that runs across SA 17 suggests that leakage from the line may have been responsible for the localized groundwater high and resulting radial discharge observed in past investigations. This water line has since been turned off.
- The groundwater flow direction in the intermediate portion of the aquifer, between the upper two silty-sand intervals (15 to 30 feet bls) suggests that local recharge may also influence this interval. Flow in the intermediate zone is toward the ditch to the south, but a component of flow also exists to the east.
- Groundwater flow direction in the deep portion of the aquifer, below the lower silty-sand interval (>30 feet), suggests that local recharge has no influence in this interval. Flow in the deep zone is toward the south and east. Contaminant migration indicates a northerly component to the deep groundwater flow further east from the site.
- Groundwater flow across the site has a strong downward component.
- Groundwater velocities at the site are low, ranging from approximately 3 to 7 feet/year depending on depth.
- Groundwater flow direction in the A and B zones (south and southeast respectively) is governed primarily by the ditch that runs south of the site. The C zone follows a more regional gradient (northeast).

- Contaminant Distribution, Fate, and Transport
  - The residual TCE in subsurface acted/acts as a source and through advection and dispersion, dissolved phase TCE is carried downgradient from the source area.
  - As TCE moves downgradient, it establishes an equilibrium with the aquifer media. The chemical equilibrium is dynamic and controls the amount of TCE sorbed versus TCE in the dissolved phase. This process retards the migration of CVOCs, which results in the CVOCs generally moving slower than groundwater.
  - A calculated concentration of potential DNAPL concentrations in soil is 342 milligrams per kilogram (mg/kg) (DNAPLANAL). The highest concentration of TCE reported in soil is 168 mg/kg. Although this value does not exceed the potential DNAPL calculated value, it does indicate the potential for elevated concentrations of TCE in soil act as a continuing source of contamination.
  - Based on the 1 percent rule-of-thumb, there exists the potential of TCE DNAPL to be present based on concentration of TCE exceeding 11,000 µg/L.
  - Reducing conditions are evident in the source area, as well as downgradient of the source area, as site data points to evidence of predominantly iron reducing

conditions, but some degree of sulfate reducing and methanogenic conditions at the site. These conditions are favorable for natural attenuation.

- The presence of TCE daughter products cis-DCE and vinyl chloride in downgradient wells relatively near the residual TCE source area indicates that reductive dechlorination is occurring readily at the site. The relatively high ratio of daughter products to parent compound (TCE) indicates a high degree of biotransformation is occurring. This is favorable for natural attenuation.
- Dehalococcoides have been detected at the site at two locations, which is highly favorable for natural attenuation, as Dehalococcoides organisms have been shown to be capable of complete reductive dechlorination of TCE and its daughter products to ethane. It is likely that Dehalococcoides can become established at other areas if additional carbon source is added.

- Impacts of IRA on Site
  - The IRA was conducted in a small area of the overall SA 17 site. Only those locations where injection occurred have been affected by the IRA.
  - The IRA was effective at reducing dissolved contaminant levels and likely also reduced the concentration of TCE adsorbed to the surface media. However, the IRA was not successful at penetrating deep into the pore structure of the aquifer media (diffusion limited) in the treatment zone, and resulted in rebound of contaminants in the source area.
  - Concentrations of TCE in groundwater will increase with time as more TCE leaches from the pore space to the bulk-phase liquid.
  - As a result of the ISCO process, substantial amounts of iron (through ferrous sulfate catalyst) and sulfate (through ferrous sulfate catalyst and sulfuric acid) were added to the treatment zone.
- Uncertainty
  - In the horizontal perspective, the extent of the groundwater plume has been characterized in most directions. The exception is the southern component of the plume, toward the ditch.
  - The ditch south of the site appears to locally control the direction of groundwater flow. It has been several years since surface water has been sampled at this location. It is unknown if the contaminant plume is discharging into the surface water.
  - The depth of contamination at the SA 17 source area has not been confirmed at locations where the highest levels of TCE have been reported in groundwater. The deepest groundwater samples were collected in this area at approximately 39 feet bls, where TCE was reported at a concentration of 48,800 μg/L. Elevated MIP responses (that is, greater than 1E+06) were noted between this depth and the top of Hawthorn depth (approximately 50 feet bls).

Remedial Action Objectives

A substantial effort in source area treatment has already been completed and it is believed that the practical limits of cost effective remediation for the purposes of complete removal of the source have been exhausted. This conclusion is supported by modeling estimates which show that even substantial reduction in the source area does not significantly alter the time of remediation for the site (Attachment A). The important conclusions from the modeling effort are:

- Further source reduction does not provide a benefit in protection of human health and the environment and does not significantly affect the overall time of remediation.
- Given the SA 17 source area is approximately 600 feet from the property boundary, the model results indicate that the source will not cause offsite groundwater concentrations to exceed Florida Department of Environmental Protection (FDEP) Groundwater Cleanup Target Levels (GCTLs) at any point in the future.
- Given the current distribution of contaminants at the site (that is, known contaminant concentrations downgradient), no location downgradient of the source area at SA 17 is anticipated to yield an offsite exceedance of GCTLs at some point in the future.

Based on these conclusions, achieving a pre-defined source mass reduction or concentration reduction is not a component of the recommended remedial action objective (RAO) for this site. However, it is important that the implemented alternative involve management of source area to prevent further groundwater migration away from the source and contamination in the zone already treated by the IRA.

Figure 1 shows a plan view of SA 17. The three main areas to consider when developing RAOs for SA 17 are:

- **Area 1—**the source area
- **Area 2—**contaminated groundwater between the source area and the property boundary
- **Area 3—**groundwater at the property boundary

RAOs have been designed for each of the areas described below.

Area 1

This area contains the highest concentrations of TCE at SA 17. TCE is present at high concentrations and is likely present as a DNAPL and, as evidenced by the results of aggressive ISCO treatment, will be difficult to remove. Three dimensional kriging of the area shows this area to be approximately 50 feet by 50 feet in area (approximate footprint of soil and groundwater exceeding 10,000 parts per billion [ppb]). High levels of CVOCs were documented down to 39 feet bls. Groundwater samples were not collected at depths greater than this, but MIP responses from this area indicate that CVOCs could be present, based on electron capture detector (ECD) responses greater than 1E+06 at depths between 40 and 50 feet).

The RAOs for this area are to:

- Apply treatment that can reduce source contaminant concentrations while minimizing CVOC migration from the area,
- Prevent plume expansion in the IRA treatment area.
- Prevent exposure of contaminants to human health and the environment.

Area 2

Area 2 represents the area between Area 1 (source area) and the downgradient property boundary. This area is not expected to have DNAPL TCE (based on 1 percent rule of thumb) but may have high concentrations of TCE and other CVOCs.

The RAOs for this area are to:

- Reduce contaminant concentrations to a level that do not threaten human health or the environment at the downgradient property boundary.
- Prevent exposure of contaminants to human health and the environment.

Area 3

Area 3 represents the area of the SA 17 site immediately near the property boundary and is characterized by groundwater with low concentrations of CVOCs.

The RAOs for this area are to:

- Prevent contaminants from crossing the property boundary at concentrations that threaten human health and the environment.
- Prevent exposure of contaminants to human health and the environment.

Target Treatment Zones

Two target treatment zones (TTZs) are recommended for the site. TTZ-1 represents Area 1 (Figure 4) and TTZ-2 represents Area 2 (the area outside of TTZ-1 but within the footprint of the contaminant plume, see Figure 2). Although investigations have not been performed to the top of the Hawthorn formation, it is assumed that groundwater contamination extends to the top of the Hawthorn (approximately 50 feet) based on the high concentrations of TCE reported at a depth of 39 feet in four samples and elevated ECD response using the MIP, in the 45- to 50-foot depth range. The depth of TTZ-1 is from the water table to the top of the Hawthorne formation.

TTZ-1 encompasses all groundwater contamination reported with TCE greater than 10,000 µg/L. However, elevated concentrations of TCE still exist outside the TTZ, as presented on Figure 4 and in the table below.

Station	TCE (µg/L)	Date Collected
17-I-12	3910	20040809
17-VD-62	3160	20040809
17-VD-58	2910	20040810
17-VD-69	2250	20040804
17-S-01	2200	20040809
17-D-03	827	20040810
17-S-04	422	20040806
17-VD-64	401	20040810
17-D-20	366	20040805
17-I-04	285	20040803
17-VD-71	283	20040811

With respect to TTZ-2, this area is characterized by the contaminant plume increasing in depth as it migrates from the source. In most cases, the most shallow groundwater in TTZ-2 is not contaminated; however, there is currently inadequate data to define the precise depth interval requiring treatment in TTZ-2.

Technology Selection

This section focuses on technology selection for TTZ-1. TTZ-2 has demonstrated to be effective in showing natural attenuation is occurring at the site. As presented in *Summary of Data Collection Activities, Study Area SA 17, Former Naval Training Center Orlando* (CH2M HILL, 2005) and based on the modeling results presented in Attachment A, no additional treatment is warranted for TTZ-2.

TTZ-1 has been the focus of numerous ISCO applications with Fenton's reagent. The Construction Completion Report concluded that, while Fenton's regent was effective in reducing CVOC concentrations, the site is still susceptible to contaminant rebound due to the presence of CVOCs in high concentrations in the source area.

Based on the meeting between NAVFAC EFD SOUTH and CH2M HILL on November 23, 2004, two alternatives were considered viable options for SA 17:

1. **Alternative 1 -** Excavation
2. **Alternative 2 -** Enhanced Reductive Dechlorination (ERD). For the purposes of this technical evaluation, this alternative has been broken down to represent two different delivery methods:
    a. **Alternative 2A:** Substrate is applied to TTZ in recirculation mode
    b. **Alternative 2B:** Substrate is applied to TTZ via injection wells

Numerous commercial substrates are available to facilitate ERD. For the purposes of this evaluation, it has been assumed that emulsified oil substrate (EOS®) will be used. EOS® is used only to represent the class of substrates and its use in this evaluation is not intended as a definitive recommendation that this substrate will be used if the alternative is selected.

The alternatives are described below.

Alternative 1—Excavation, Onsite Treatment, and Backfill of Treated Soil

Alternative 1 provides for the removal of source contamination to a depth of approximately 50 feet bls. This includes the installation of a sheetpile retaining cell, excavation of soil within this cell, treatment of the excavated soil, and backfill of the excavation with treated soil. The remedial action objectives are met under Alternative 1 by providing removal of significant amounts of source contamination (TCE) and replacing it with soil that is cleaner as a result of ex situ treatment. This methodology is expected to remove the most significant portion of the contaminant source and also result in a substantial decrease in the amount of TCE migrating from the source area.

To remove the source contamination identified in the investigations, a circular sheetpile cell would be constructed to approximately 56 feet in diameter and driven to a minimum depth of 60 feet to retain the subsurface soil during excavation. It is estimated that approximately 4,600 cubic yards (CY) of contaminated soil would be excavated using a clamshell attached to a crane or similar piece of equipment. Excavated soil will be placed on a lined stockpile area adjacent to the excavation. The stockpile pad would be constructed so that excess water from the soil will be contained and allowed to drain back into the excavation.

The soil would be treated using an ex situ chemical oxidation process that destroys CVOCs by converting them into carbon dioxide and water.

This proposal assumes treatment of contaminated soil in a batch mix operation using a pugmill or other suitable mixing equipment. Potassium permanganate and other additives will be mixed with the contaminated soil at a ratio of approximately 14 pounds (lbs) of treatment reagent per ton of contaminated soil. Potassium permanganate will comprise approximately one half of the 14 lbs of treatment reagent per ton of contaminated soil. Vendor (Soil Savers) experience with this technology shows that TCE can be removed to levels below analytical detection limits.

Treated soil will be staged in stockpiles and sampled/tested approximately 2 days after treatment to verify cleanup goals. Confirmation sampling will be conducted to verify treatment effectiveness. Groundwater that remains in the excavation area after the soils have been removed will be treated by mixing with potassium permanganate and confirmatory samples will be collected to verify treatment effectiveness.

Soils treated successfully by the ex situ process will be backfilled in the open excavation, after the excavation water has been treated. The treated soil will be placed in the excavation by mobile equipment. The material placed below the water table will be placed without any compaction effort. Once the backfill reaches an elevation greater than the water table, the backfilled material would be compacted at pre-selected lift intervals (to be defined in the remedial design phase of work). Following backfilling of the excavation, the sheetpiling will be removed and disturbed surfaces will be graded to match the natural contours of the area and then vegetated.

Alternatives 2A and 2B—Enhanced Reductive Dechlorination Using Emulsified Oil Substrate

Two alternative methods of applying enhanced ERD technology have been evaluated in this report and their cost estimates are included as Alternatives 2A and 2B.

Alternative 2A is injection of EOS® in conjunction with recirculation of groundwater, and Alternative 2B is injection of EOS® followed by introduction of chase water to propagate the EOS® injectate further out into the subsurface.

EOS® Alternative Description

The ERD approach being proposed for the TTZ at SA 17 involves the injection of emulsified oil substrate (EOS®) into the subsurface in three sub-zones of the TTZ, the shallow zone (approximately 5 feet to 15 feet bls), intermediate zone (approximately 15 to 30 ft bls), and the deep zone (approximately 30 to 50 feet bls).

EOS® is a patented substrate that consists of emulsified soybean oil, with oil droplets small enough to pass through most pores in the soil. It is a biodegradable, non-hazardous substrate with low viscosity, and is expected to be a long-lasting natural time-release additive to enhance the bioremediation process. The EOS® patent is held by Solutions-IES, Inc., of Raleigh, North Carolina. The methodology of EOS® treatment involves introduction of this food-grade emulsified oil emulsion into the subsurface. The oil emulsion slowly dissolves over time enhancing the long-term anaerobic biodegradation of the chlorinated solvents. Product literature on the EOS® substrate indicates that it can be injected into "hot spots" throughout the plume (as in the case of SA 17) or as a permeable reactive barrier to contaminant migration. The EOS™ process successfully arrests plume migration, reducing additional assessment and remediation expenses, and is expected to lower operation and maintenance costs while being effective in heterogeneous soils.

Alternative 2A – EOS® Injection with Recirculation of Treated Groundwater

Under this alternative, EOS® will be injected into each of the three sub-zones of the shallow aquifer at SA 17. Based on consultations with Solutions-IES, Inc., for the silty sands at SA 17, a radius of influence (ROI) of approximately 15 feet from the injection point has been assumed. The TTZ for the source area has been identified as being 50 feet wide, 50 feet long and 50 feet deep. Based on the ROI of 15 feet, four injection points are required to cover the 50-foot by 50-foot footprint of the TTZ. The injection depths will be selected to provide the best contact of the substrate with areas of high TCE contamination in the subsurface. Based on the depths of the three sub-zones, four injection wells each are being proposed within the shallow zone (5 to 15 feet bls) and the intermediate zone (15 to 30 feet bls). Four nested pairs of injection wells are being proposed within the deep zone (30 to 50 feet bls) due to the greater thickness of this sub-zone. A total of 16 injection wells has been assumed in the cost estimate for this option.

Based on initial assumptions of aquifer characteristics, two 4-inch extraction wells each within the shallow and intermediate zone, and two nested pairs of extraction wells within the deep zone, are being proposed, for a total of eight extraction wells. Based on initial assumptions of the yields in this aquifer, a flow rate of 3 to 5 gallons per minute (gpm) has been assumed as a recirculation flow rate.

The recirculation process will be implemented using a process trailer which includes pumps, tanks, piping, and fittings along with necessary safety appurtenances. Additional aquifer tests may be necessary to gather better data to determine the balance between injection and extraction rates.

An initial dosing of EOS® will be done in the injection wells. The extracted groundwater will be dosed with EOS® and re-injected into the TTZ through the injection wells. The temporary gradient change due to the extraction is expected to aid in better distribution of the substrate in the TTZ. One part of EOS® will be diluted with 4 to 6 parts of water before injection.

Consultations with Solutions-IES, Inc., have indicated that the injected substrate reaches the extraction wells within 1 to 2 weeks of recirculation. After the extraction water indicates the presence of EOS®, the injection and recirculation will be terminated. Based on calculations included in the cost estimate tables, approximately 20 drums of EOS are expected to be required to treat the TTZ at SA 17.

Alternative 2B- EOS® Injection Followed by Chase Water

The elements of this alternative are similar to those of Alternative 2A, but without extraction and recirculation of groundwater, and with the introduction of direct chase water. The chase water would be used to help push the substrate adequately within the subsurface radius of influence of the injection wells.

The number of injection wells and injection flow rates are expected to be similar to those of Alternative 2A. No extraction wells will be installed, and the process trailer will not require vacuum pumps, piping and temporary storage tanks for extracted groundwater. A fire hydrant or other source of fresh water will be identified to supply adequate flow of water.

Figures presented at the end of Attachment B (Attachment B-4) show the proposed locations of the injection wells for Alternatives 2A and 2B, and the extraction wells for Alternative 2A. These locations may be modified during final design of this remedy.

Necessary well installation and underground injection permits will be applied for and secured from FDEP, prior to implementation of these alternatives.

The EOS® injections at SA 17 are being proposed to be performed utilizing 2-inch wells. The feasibility of using DPT borings to introduce the substrate into the subsurface will be evaluated during final design of the bioremediation alternative, should this alternative be chosen as the source control remedy for this site.

Comparison of Alternatives

The alternatives were evaluated on the basis of effectiveness, implementability, cost, uncertainty, and cost. An overview of the alternative evaluation is presented in Table 1.

Effectiveness

On the basis of effectiveness, Alternative 1 provides for an immediate achievement of the RAOs for Area 1, by immediately reducing contaminant levels and migration from the source area. Alternatives 2A and 2B require time for development of microbial communities to be come effective in reducing contaminant concentrations. Alternative 2A is expected to achieve the RAO sooner than Alternative 2B due to the superior substrate delivery system. However, it should be noted that time to achieve RAOs is not a significant factor at this site because the velocity of groundwater is slow at this site (3 to 7 feet/year) and it is not expected that groundwater will ever exceeds GCTLs offsite.

Alternative 1 provides for more certainty in effectiveness than Alternatives 2A and 2B. The RAO for Area 1 will be achieved with the completion of this alternative. Additional applications of substrate may be required in the future to sustain effective ERD.

Alternative 1 is expected to reduce contaminant concentrations in the source area to a greater degree and result in a commensurate decrease in migration over time. The source of contamination is significantly reduced via the ex situ treatment process with Alternative 1, whereas with the other two alternatives, the ERD process will convert the TCE to ethene and ethane over a period of time. There is a potential that the ERD process could be stalled at cis-1,d-dichloroethene or vinyl chloride. The body of literature available on ERD processes for TCE, however, strongly supports the notion that eventually complete dechlorination will occur with ample substrate.

The challenge with in situ treatment at Area 1 is being able to effectively get the treatment process to reduce contaminant levels in small pore spaces where contaminants reside. Even if Alternatives 2A and 2B are unable to do this, the process will result in a "bio-filter" being established around the area to control migration of contaminants. With Alternative 1, the entire TTZ is excavated and treated and the treated material will have substantially less TCE when backfilled.

Implementability

On the basis of implementability, Alternatives 2A and 2B are much simpler and easier to implement than Alternative 1. With Alternative 1, heavy equipment will be brought onsite and sheetpiling will be driven into the ground. Additional testing of the keying layer of the sheet piling may be required to ensure it will adequately support the excavation area. Given the complexity of Alternative 1, there is increased potential for a safety incident onsite. However, with proper engineering and planning, these risks can be mitigated.

Wile the excavation is open, there is a potential for transfer of TCE to air via material handling processing and volatilization of TCE from the water in the open excavation. This activity would have to be monitored prior to implementation to ensure protection of human health during the implementation phase and protection of air quality. It is likely that this work would have to be accomplished with Level B or C personal protective equipment (PPE) of site workers.

All three alternatives are expected to require some type of permitting or monitoring to assure compliance with the zone of discharge variance. Compliance monitoring for Alternative 1 is expected to only consist of metals monitoring, to ensure that the potassium permanganate used in treatment of the water and soil does not cause an exceedance of groundwater standards.

With respect to Alternatives 2A and 2B, the monitoring is more complicated. The specific substrate to be used in the remedy will have specific monitoring requirements. In the case of this report, it has been assumed that EOS will be used. FDEP has indicated that monitoring of an EOS® constituent, Polysorbate 80, will be required. This is not a typical target parameter with a U.S. Environmental Protection Agency (EPA)-approved laboratory method. There are several options for Polysorbate monitoring, including using non-environmental methods for analysis, using more comprehensive analytical methods (for example, those applied to surfactants), or providing FDEP mass balance information to demonstrate compliance with FDEP criteria for Polysorbate 80 in water.

Uncertainty

Alternative 1(Excavation):

The following uncertainties have been identified for Alternative 1:

- Adequacy of keying layer to support sheetpiling
- Monitoring requirements for air
- Level of PPE required for site personal
- Potential air impacts on surrounding area
- Depth of treatment required in TTZ (currently assumed to be 50 feet)

Alternative 2A (ERD using EOS® in Recirculation Mode)

The following alternatives have been identified for Alternative 2A:

- Ability to affectively monitor for Polysorbate 80
- Need for reapplication of substrate in the future
- Depth of treatment required in TTZ (currently assumed to be 50 feet)

Alternative 2B (ERD using EOS® in Direct Injection Mode)

The following alternatives have been identified for Alternative 2B:

- Ability to affectively monitor for Polysorbate 80
- Need for reapplication of substrate in the future
- Depth of treatment required in TTZ (currently assumed to be 50 feet)

Cost

On the basis of costs, Alternatives 2A and 2B are more cost effective than Alternative 1. While Alternative 1 provides for complete removal of contaminants in the source area and achieving RAOs faster, there is little advantage to the incremental increase in contaminant reduction expected with Alternative 1 because the site will require long-term monitoring. On the basis of modeling results presented in Attachment A, monitoring will be required for a long time.

Table 2 summarizes capital costs for each of the three alternatives. Detailed cost estimates are presented in Attachment B (Attachment B-1 and B-2).

Each of the three alternative costs only focus on capital construction costs. The following factors have not been added to the cost estimate because they are considered to be common to all three alternatives and would therefore provide no additional value with respect to assessing cost:

- Long-term monitoring and reporting
- Land-use controls
- Five year reviews
- Future optimization studies

Performance Objectives

Performance objectives for Areas 1, 2, and 3 are described below.

Area 1

Alternative 1

For the excavation alternative, the performance objective is to reduce the TCE soil concentration to non-detectable levels. Prior to backfilling of the excavation with treated soil, it will be tested to ensure the target treatment goals of the soil treatment have been achieved. Post treatment monitoring TTZ-1 will not be required, after the excavation has been filled with treated soil.

Alternatives 2A and 2B

The performance objectives for both Alternatives 2A and 2B are for sustained reduction in contaminant concentrations over time reducing the contaminant flux from the source area. An additional performance objective for Alternative 2A is operation of the recirculation system until EOS® is detected at extraction wells.

When it becomes apparent that the indicator parameters show declined system performance, the application of additional substrate should be considered. It should be noted, however, that several rounds of data are often necessary to make this determination. Alternatives 2A and 2B will be effective as long as it is cost-effective to add substrate to the target treatment area. At some point in the future, it may be more appropriate to simply let natural attenuation continue without the addition of substrate.

Monitoring parameters for Alternatives 2A and 2B will consist of typical MNA parameters as well as occasional microbial analysis.

Area 2

The performance objective for Area 2 is for a continuation of conditions that are favorable for natural attenuation in groundwater. TTZ-2 will be monitored, as required, to evaluate the effectiveness of natural attenuation. Given the slow rate of groundwater movement at the site, and the minimal potential for offsite migration, annual monitoring is recommended at this point. The monitoring parameters will consist of CVOCs, typical MNA parameters, and occasional microbial analysis.

Area 3

The performance objective for Area 3 is to ensure CVOCs do not cross the property boundary at concentrations that threaten human health or the environment. Monitoring will be performed to document compliance with the performance objective for Area 3. As with Areas 1 and 2, annual monitoring is recommended. CVOCs are the only target parameters recommended at this time. Additional monitoring wells will be required to evaluate this performance objective.

Optimization and Exit Strategies

Recommendations on activities for optimization can be provided after the recommended alternative is determined. However, some of the optimization strategies that will be considered are:

- Reducing the frequency of monitoring
- Reducing the target analytes list for monitoring
- Continual future evaluation of the implemented remedy to determine refinements that may be appropriate in the future

There are no practical near term exit strategies for the site. Given the size of the plume, it would be cost-prohibitive to treat the entire plume to the degree necessary to accelerate the time required for long-term monitoring.

Recommendations

Based on the information presented in this report, the following recommendations are provided:

- Alternative 2A should be implemented because it provides for a cost-effective means of meeting the RAOs and allows for an indication of adequate substrate delivery with the recirculation process.

- Monitoring wells should be placed at the downgradient boundary to ensure the RAOs for Area 3 are achieved.

- Several monitoring wells should be placed in Area 1, at a depth of 40 to 50 feet, to evaluate the level of CVOC contamination in this area, prior to finalizing remediation plans.

- Groundwater samples near the ditch and in the ditch should be collected to delineate the extent of contamination. These wells have not been sampled since 1998.

- The need for a risk assessment should be evaluated prior to finalizing the Record of Decision. It is expected that the risk assessment would not change the recommendations of this optimization report. However, as the evaluation of risks is a substantive component of a Record of Decision (ROD), some level of quantitative risk evaluation would be necessary to support a final ROD for SA17.

- Groundwater monitoring wells south of the SA 17 site should be collected to evaluate for potential groundwater contamination in this area.
- Surface water samples should be collected from the ditch south of SA 17 to determine if there is an exposure pathway for contaminated groundwater in this area.
- The monitoring well network should be upgraded to replace wells that are inadequate.

References

CH2M HILL. 2000. *Phase I and II Data Report for Study Area 17, NTC Orlando.* May.

CH2M HILL. 2003. *Construction Documentation Report for the Interim Remedial Action at SA 17.*

CH2M HILL. 2004. *CVOC Source Area Investigation and Focused Feasibility Study*.

CH2M HILL. 2005. *Summary of Data Collection Activities, Study Area SA 17, Former Naval Training Center Orlando.*

Department of the Navy. 2003.

Naval Facilities Engineering Command. 2004. *Guidance for Optimizing Remedy Evaluation, Selection, and Design***.**

Tables

TABLE 1
Summary of Technologies for SA17

Alternative	Effectiveness	Implementability	Uncertainty	Costs
1. Excavation	• Effective • Will remove defined volume and mass of contamination • Certainty in results • Immediate achievement of RAOs	• Requires significant engineering and planning, and onsite activity • Involves substantial site activity • Permitting will be required	• Integrity of Hawthorne as key medium for shoring • Air quality issues	• Significantly more expensive than other alternatives
2a. ERD with Recirculation	• Effective • Will achieve RAOs in reasonable period of time • Simple process involves minimal disruption at site • Effective delivery system that provides for additional assurance that substrate has been effectively applied to TTZ • May require additional applications	• Permitting will be required • Ability of process to effectively reduce contaminant concentrations in interstitial pore space of source area	• Time to achieve effective contaminant reduction and migration control • Substrate demand over time • Period of DCE and VC accumulation before DHC ramp up	• Costs for future reapplication of substrate, if necessary, not included in cost estimate
2b. ERD with Direct Injection	• Effective • Will achieve RAOs in reasonable period of time • Simple process involves minimal disruption at site • May require additional applications	• Permitting will be required • Ability of process to effectively reduce contaminant concentrations in interstitial pore space of source area	• Time to achieve effective contaminant reduction and migration control • Substrate demand over time • Period of DCE and VC accumulation before DHC ramp up	• Costs for future reapplication of substrate, if necessary, not included in cost estimate.

TABLE 2.
Comparison of Costs for Source Reduction Alternatives at SA17

COST ESTIMATE OF CORRECTIVE ACTION OPTIONS

SA17 Source Reduction Alternatives

Site:	Former Naval Training Center, Orlando - Study Area 17	**Base Year:**	2005
Location:	Orlando, Florida	**Date:**	February 2005
Phase:	SA17 Remediation		

	Alternative 1 **Soil Excavation In the Treatment Zone**	Alternative 2A **Enhanced Bioremediation with EOS using Recirculation**	Alternative 2B **Enhanced Bioremediation with EOS using Inject and Chase Method**	
Total Project Duration (Years)	1	1	1	
Total Capital Cost	$1,193,000	$446,000	$394,000	
Total Present Valve of Alternative	**$1,193,000**	**$446,000**	**$394,000**	
		One Injection Event	One Injection Event	
		Baseline Monitoring only	Baseline Monitoring only	

Disclaimer: The information in this cost estimate is based on the best available information regarding the anticipated scope of the remedial alternatives. Changes in the cost eleme
are likely to occur as a result of new information and data collected and potential revisions in the design assumptions

Figures

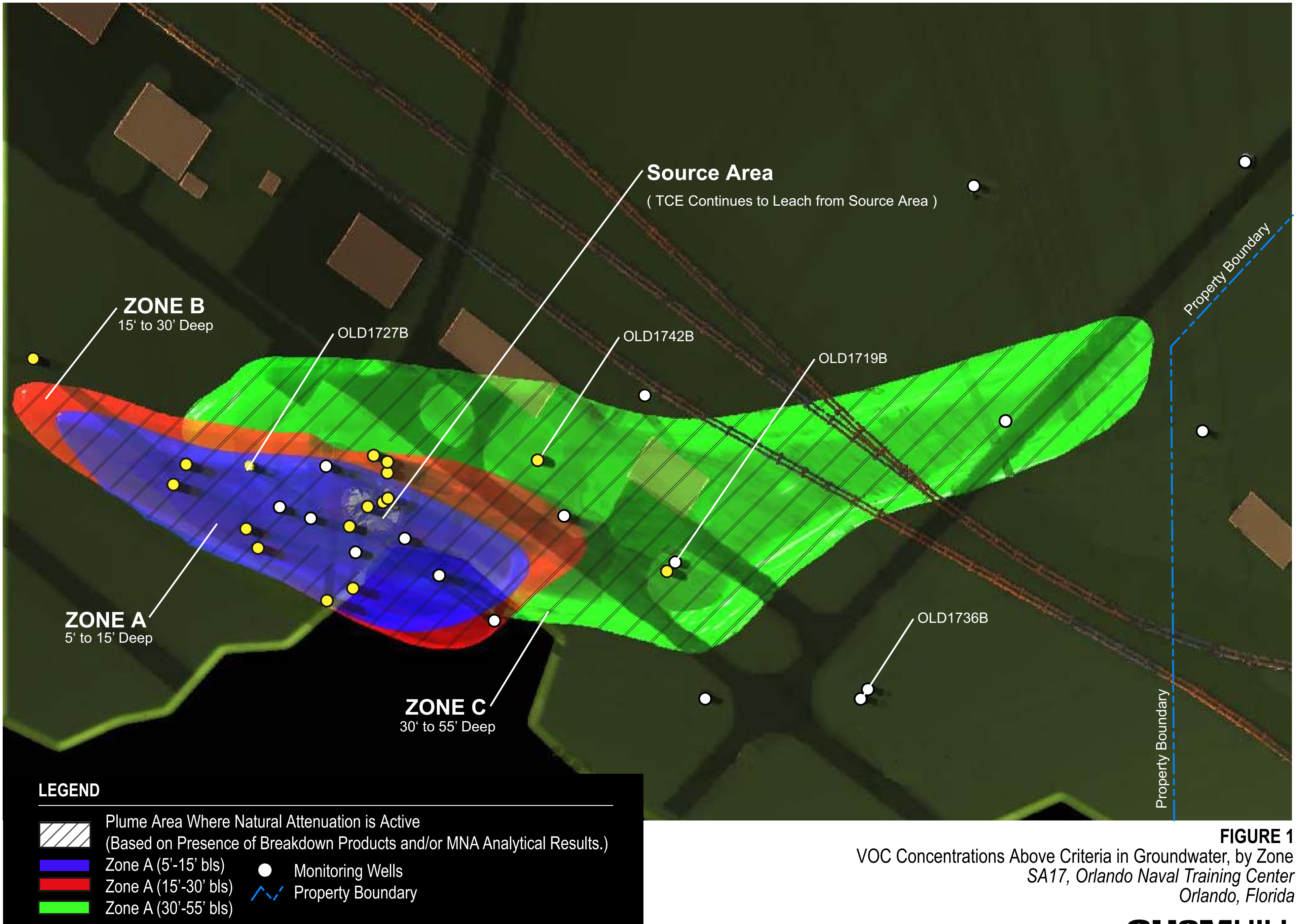


FIGURE 1
VOC Concentrations Above Criteria in Groundwater, by Zone
SA17, Orlando Naval Training Center
Orlando, Florida

CH2MHILL

E012005033GNV \ SA17_F13_Topo_3D_Representation.ai

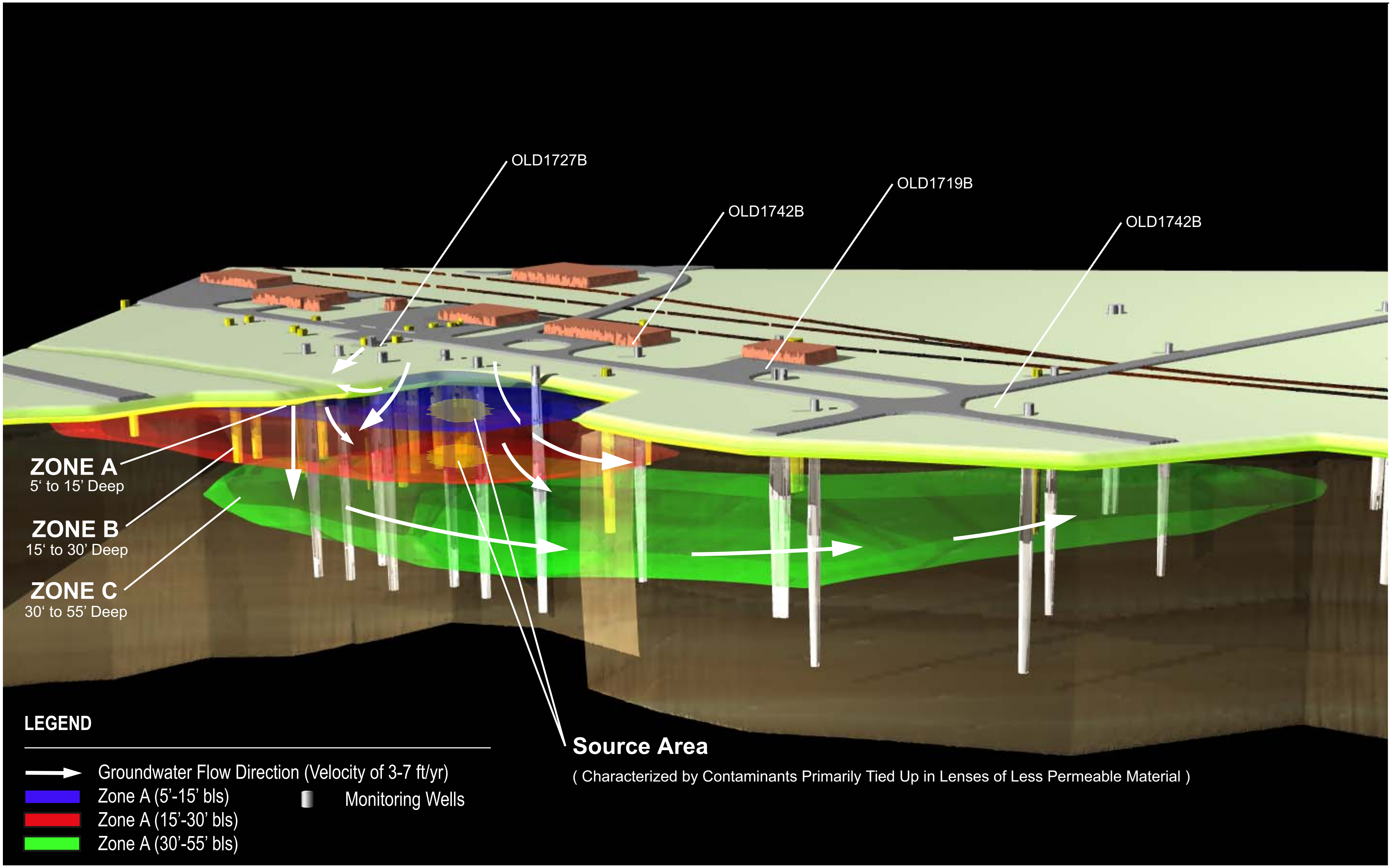
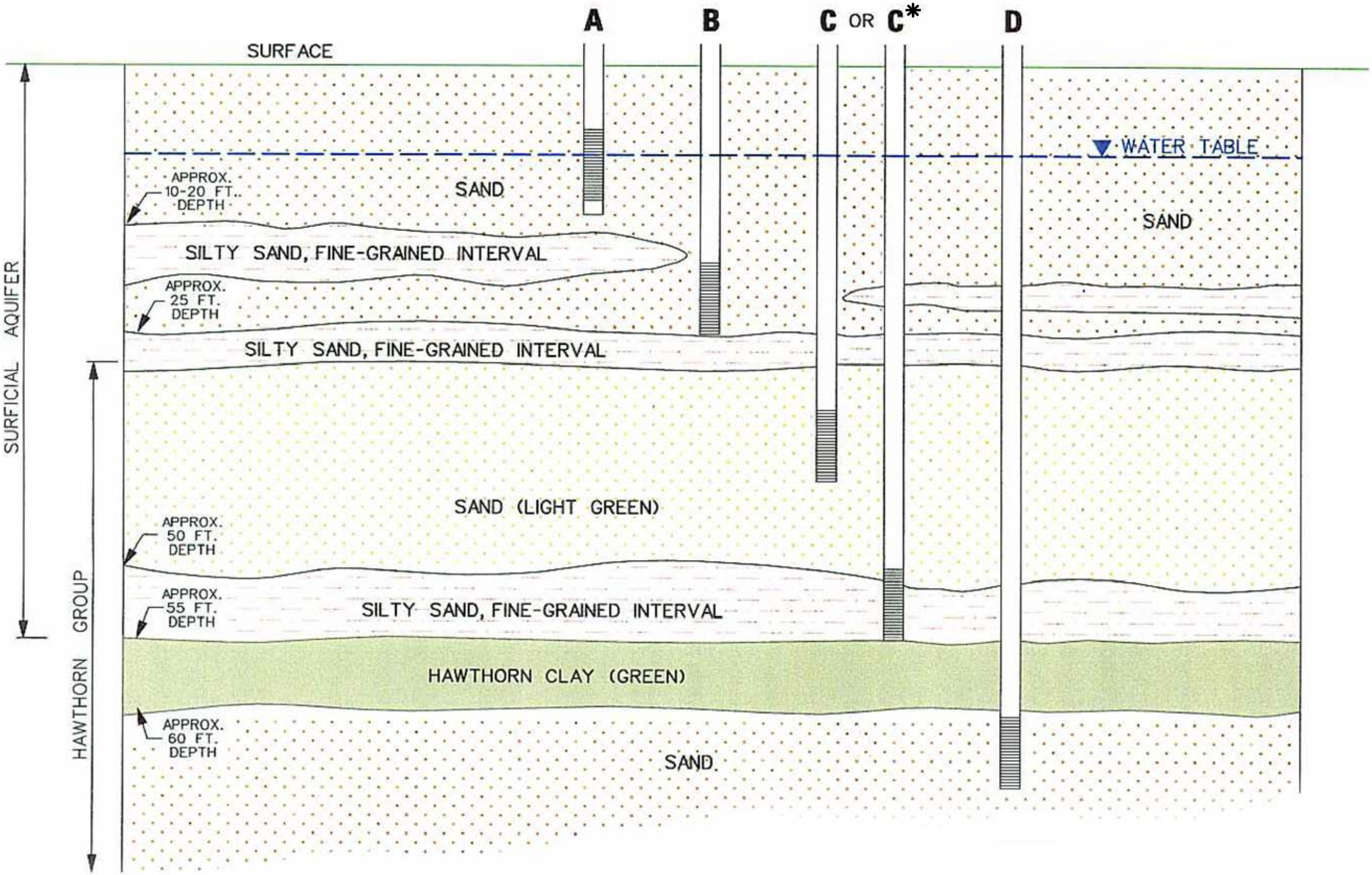


FIGURE 2
VOC Concentrations Above Criteria in Groundwater
SA17, Orlando Naval Training Center
Orlando, Florida

CH2MHILL

E012005033GNV \ SA17_F12_3D_Representation.ai



Notes:

1) "C" and "D" Wells May or May Not Be Double Cased Depending on Location.

* Wells OLD-17-25C and OLD-17-28C

FIGURE 3
Well Depth Schematic Study Area 17 - McCoy Annex
SA17, Orlando Naval Training Center
Orlando, Florida

CH2MHILL

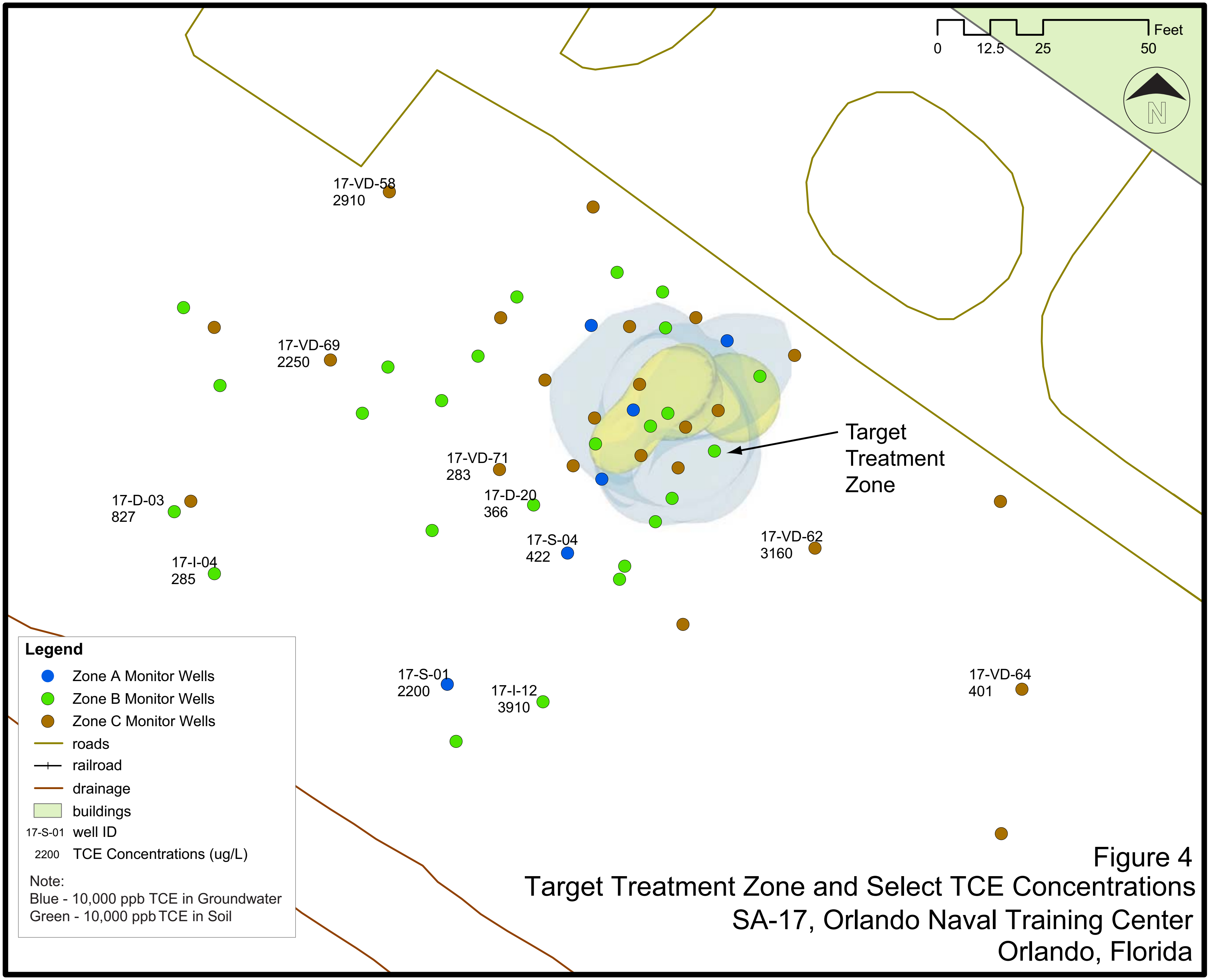


Figure 4
Target Treatment Zone and Select TCE Concentrations
SA-17, Orlando Naval Training Center
Orlando, Florida

Attachment A

Attachment A - Determination of Time of Remediation of TCE using Source DK and NAS Software, Naval Training Center, SA-17

Two models were evaluated for the purposes of estimating the Time of Remediation (TOR) of the groundwater plume. The TOR estimates the timeframe required to achieve a pre-determined cleanup level at the source of contamination. One of the two models is also capable of estimating Time of Stabilization (TOS) for the groundwater plume. TOS refers to the time required to achieve a pre-determined compliance or target concentration at a fixed distance downgradient of the source area.

Natural Attenuation Software (NAS) provides routines to calculate both TOS and TOR. Source DK was only used to calculate TOR. The application of each model is discussed in the following section.

Natural Attenuation Software (NAS) (Version 1.2, 2001)

NAS is a Visual Basic interface that was designed to calculate estimates for TOR based on site characterization data for sites contaminated with either fuels or chlorinated solvents. NAS calculates natural attenuation capacity (NAC), TOS, and TOR.

Calculation

Site specific data required to run the model include:

- Hydrogeology (hydraulic conductivity, hydraulic gradient, and porosity)
- Fraction of Organic Carbon (to calculate retardation factors)
- Detected contaminant concentrations in 3 or more consecutive wells along centerline of the plume
- Concentrations for oxygen, iron (II), and sulfate in one or more wells along the centerline of the plume. Other choices are nitrate, manganese (II), sulfide, methane, and hydrogen.
- Source width

Required for TOS window

- Location of downgradient point of compliance (POC)
- Regulatory target concentration (RTC) at the POC

Required for TOR window

- Dimensions of source NAPL
- Mass fraction of each contaminant in the NAPL
- Background concentrations of each electron acceptor
- An estimate of NAPL mass
- Maximum allowable concentration at the contaminant source area

Assumptions: NAS assumes that groundwater flow is uniform and unidirectional. Decay rate can only be calculated given the NAC input values.

Input Parameters:

- NAPL mass = 93 lbs (42 kg), mass of CVOCs calculated using EVS model and June 2003 data. Note, this is the total mass estimate of TCE present at SA17 and represents a conservative basis for modeling.
- Hydraulic conductivity (avg)= 1.5 ft/d
- Hydraulic gradient = 0.002 ft/ft
- Total Porosity = 0.3, Effective porosity = 0.25
- Groundwater Velocity (avg)= 0.012 ft/d
- Contaminated aquifer thickness = 20 ft
- Flow path included wells: VD62, VD64, 43C, 45C, 20C (Zone C) and D25

The above values were selected to represent the site in the model. There is a wide range of data available for many of the above parameters. The values presented above are reasonable for the purposes of model, which were to evaluate the impact of Time of Remediation and Time of Stabilization under different scenarios.

TOS Results

The TOS effort completed with this modeling exercise was designed to determine the distance from a contaminant source that would result in no unacceptable concentrations of contaminants migrating offsite. TOS output includes a range of years given the input contaminant concentration of the project site.

Time of Stabilization was calculated assuming a range of feet to a point of compliance (POC) (100 to 600 feet), a range of source concentrations (2000, 20000, and 40000 μg/L), 30′ source width, and 5 μg/L screening criteria.. The model can be used to compare distances to the POC and their respective TOS. The results of the model runs are presented in the tables below. An example of model output is presented at the end of this appendix.

Time of Stabilization (TOS) Output (2000 µg/L Source Concentration)

POC (ft)	Total NAC, Ferrogenic (1/ft)	Target Concentration (µg/L)	TOS (yrs) - Maximum	TOS (yrs) – Average	TOS (yrs) - Minimum
100	0.0113	25	117.6	47.0	18.6
200	0.0113	122	235.2	94.1	37.1
300	0.0113	503	352.8	141.1	55.7
400	0.0113	NA	No Reduction Required		
500	0.0113	NA	No Reduction Required		
600	0.0113	NA	No Reduction Required		

Time of Stabilization (TOS) Output (20000 µg/L Source Concentration)

POC (ft)	Total NAC, Ferrogenic (1/ft)	Target Concentration (µg/L)	TOS (yrs) - Maximum	TOS (yrs) – Average	TOS (yrs) - Minimum
100	0.035	259	110.0	44.0	17.4
200	0.035	13,394	220.0	88.0	34.7
300	0.035	NA	No Reduction Required		
400	0.035	NA	No Reduction Required		
500	0.035	NA	No Reduction Required		
600	0.035	NA	No Reduction Required		

Time of Stabilization (TOS) Output (40000 μg/L Source Concentration)

POC (ft)	Total NAC, Ferrogenic (1/ft)	Target Concentration (μg/L)	TOS (yrs) - Maximum	TOS (yrs) – Average	TOS (yrs) – Minimum
100	0.0421	524	108.0	43.2	17.1
200	0.0421	NA	No Reduction Required		
300	0.0421	NA	No Reduction Required		
400	0.0421	NA	No Reduction Required		
500	0.0421	NA	No Reduction Required		
600	0.0421	NA	No Reduction Required		

The target concentration is the required source contaminant concentration (C) that NAS calculates. It is used for comparison to the user-provided initial concentration (Co) in the calculation of TOS. A longer POC corresponds to a higher target concentration as can be seen in the first model run above (25 μg/L at 100′ versus 122 μg/L at 200′). Once the user increases the POC to 400′, the target concentration is calculated as not applicable, which means that the plume would reach stabilization by that distance (TOS column corresponds with "No Reduction Required").

It should be noted that the model does not allow for comparison of increasing source concentration by adjustment of that value. By increasing the source concentration, there are other variables that are calculated (NAC and decay constant), and therefore, do not allow a precise comparison of data based on the alternation of varying one input parameter. For instance, comparing the 100 feet POC for 2000 μg/L and 20000 μg/L source concentrations, the TOS actually decreases (47.0 to 44.0 years, respectively). The total NAC (natural attenuation capacity) is included to show that this value also slightly increases. However, as the NAC is calculated by considering the slope concentration as a function of distance, any increase in concentration of the first point (the source) strongly effects the slope and results in artificially decreasing the TOS.

Other tests were performed to verify this observation. For example, the redox conditions at the source well are presently (and for the calculations) ferrogenic. By changing the condition to methanogenic, the TOS did not change. In addition, changing the source concentration from TCE to VC (at the 2000 μg/L concentration) did not change the observation.

The important conclusions from the above model runs are:

- Given the SA17 source area is approximately 600 feet from the property boundary, the model results indicate that the source will not cause an offsite groundwater concentrations to exceed GCTLs at any point in the future; and

- Given the current distribution of contaminants at the site, no location downgradient of the source area at SA17 is anticipated to yield an offsite exceedance of GCTLs at some point in the future.

TOR Output

The TOR portion of the modeling effort was meant to address the time of remediation required to achieve a compliance concentration of 5 μg/L at the source area under assumed mass reductions scenario's.

A total of six scenarios were evaluated to evaluate TOR:

- Plan 1 assumes no initial removal of contaminants prior to allowing MNA to stand alone as a remedial activity
- Plan 2 assumes 25% source reduction prior to allowing MNA to stand alone as a remedial activity
- Plan 3 assumes 50% source reduction prior to allowing MNA to stand alone as a remedial activity
- Plan 4 assumes 75% source reduction prior to allowing MNA to stand alone as a remedial activity
- Plan 5 assumes 85% source reduction prior to allowing MNA to stand alone as a remedial activity
- Plan 6 assumes 95% source reduction prior to allowing MNA to stand alone as a remedial activity

The output also allows for a range of initial contaminant concentrations by inputting the initial source mass value with a ± % deviation. At SA-17, the average source mass concentration , calculated using the EVS Model , was 93 lbs and a 50% deviation was used (46.5, 93.0, and 139.5 lbs). The resulting years to reach the 5 μg/L screening criteria using Plan 1 would be from 61.1 to 63.5 years based on the range of initial contaminant concentrations. Results of the 18 model runs is presented below. As can be seen by review of this data, there is very little change in the TOR estimates by altering the initial source mass or by applying reductions of source mass (e.g., through remediation).

Time of Remediation (TOR) Source Removal Plan Table (yrs)

NAPL Mass (TCE) (lb)	Plan 1 – 0% Removed	Plan 2 – 25% Removed	Plan 3 – 50% Removed	Plan 4 – 75% Removed	Plan 5 – 85% Removed	Plan 6 – 95% Removed
139.5	63.5	62.6	61.7	60.8	60.5	59.9
93.0	62.3	61.7	61.1	60.5	60.2	59.9
46.5	61.1	60.8	60.5	60.2	59.9	59.9

The TOR output for Plan 1 would be best compared to the Source DK output below.

Source DK (Version 1.0, April 2004)

Source DK is a remediation timeframe decision support system. It utilizes three approaches to estimate time of remediation and the uncertainty in the timeframe estimate. The first approach (Tier 1) estimates time of remediation based on extrapolation, a record of concentration versus time. The second and more complex approach (Tier 2) uses a box model from a source mass estimate, mass flux constituents leaving the source zone, and biodegradation in the source zone. Tier 2 follows first order decay pattern, and calculates the time in years to achieve the dissolved constituent concentration value. The final approach (Tier 3) employs a process model to predict a remediation timeframe based on the amount of naturally flowing groundwater required to flush out dissolved-phase and NAPL constituents from a source zone. While Source DK is primarily used for natural attenuation processes, it can also be used to estimate source lifetimes for groundwater pump-and-treat technologies.

For this report Tier 2 and Tier 3 models were investigated. Tier 1 was not used due to the lack of adequate spatially distributed analytical data for the remediation model and the simplicity of the output (the model extrapolates a trend of concentration versus time to reach a TOR). The Tier 2 model becomes more complex by utilizing a first order decay calculation, which is then used to determine a TOR. This model would be more accurately compared to the NAS output described above, due to similar input value requirements of both models. The Tier 3 Model was included in this discussion for comparison purposes. This model determines a remediation timeframe given a contaminated groundwater zone without any NAPL or matrix diffusion (SA-17 presently contains NAPL). In short, the model assumes all contamination are in the dissolved phase.

Calculation

Data entry for the box model (Tier 2) approach includes:

- Hydrogeology (darcy velocity, hydraulic conductivity, hydraulic gradient)
- Source Characteristics (Average source groundwater concentration, source length, source width, source thickness)
- Source Decay Constant (can be entered directly or calculated using the following:
    1. Source Mass
    2. Source Zone Biodegradation (Choose either no biodegradation, biodegradation rate constant, or biodegradation rate derived from electron acceptor by-product data)
- Time for output (# years to plot the data)
- Field data for comparison (concentration versus time analytical data can be added to compare predicted to actual output)
- See example at end of appendix for input parameters

Source DK Tier 2 Model

Source DK output for 4 scenarios using the box model is presented below. The scenarios are:

Matrix 1 assumes no source decay constant and no biodegradation

Matrix 2a assumes a source decay constant (recommended by Source DK, average for TCE) and no biodegradation

Matrix 2b assumes a source decay constant (calculated) and no biodegradation

Matrix 3 assumes a source decay constant (calculated) and biodegradation (recommended by Source DK)

These matrices were created to compare different times of remediation based on various degradation constants (source decay rate and biodegradation). The source decay rate describes how quickly the dissolved concentrations in the source zone decline over time. This does not represent the attenuation of constituents that have left the source zone or the biodegradation. The biodegradation rate constant is the rate coefficient describing the biodegradation of dissolved constituents (a calculated relationship between microbial populations and a substrate). Both constants contribute to the transformation or removal of contaminants in a source zone.

Matrix 2 is described by two scenarios. Source DK allows for several scenarios in calculating the source decay constant. The user has the option to enter the source decay constant directly, or by calculation using the source mass (Methods 1-4). Matrix 2a utilized Source DK's recommended value for TCE (0.11 yr^{-1}). Matrix 2b used the source mass estimated by backcalculating to maintain the same source decay constant.

Matrix 3 involves the contribution of both constants, and since SA-17 does not have a calculated site specific biodegradation rate constant, the average rate recommended by Source DK for TCE was used. It should also be noted that once the biodegradation constant is entered the source decay constant will recalculate (compare Matrix 2b to 3, 0.022 to 0.18)

Matrix 1: No Decay Constant/No Biodegradation

	Input				Output		
			Calculated Constant Input Parameters		Estimated Time to Reach 5 µg/L		
Output	Source Conc. (µg/L)	Decay Constant (1/yr)	Source Mass (kg)	Biodegradation (lambda, 1/yr)	Low End (yrs)	Mid Range (yrs)	High End (yrs)
1	2000	0	NA	NA	>500	>500	>500
2	20000	0	NA	NA	>500	>500	>500
3	40000	0	NA	NA	>500	>500	>500

Matrix 2a: Source Decay Constant/No Biodegradation

	Input				Output		
			Calculated Constant Input Parameters		Estimated Time to Reach 5 μg/L		
Output	Source Conc. (μg/L)	Decay Constant (1/yr)	Source Mass (kg)	Biodegradation (lambda, 1/yr)	Low End (yrs)	Mid Range (yrs)	High End (yrs)
4	2000	0.11	NA	NA	5	54	>500
5	20000	0.11	NA	NA	8	75	>500
6	40000	0.11	NA	NA	8	82	>500

Matrix 2b: Source Decay Constant (calculated)/No Biodegradation

	Input				Output		
			Calculated Constant Input Parameters		Estimated Time to Reach 5 µg/L		
Output	Source Conc. (µg/L)	Decay Constant (1/yr)	Source Mass (kg)	Biodegradation (lambda, 1/yr)	Low End (yrs)	Mid Range (yrs)	High End (yrs)
7	2000	0.022	4.26	NA	27	274	>500
8	20000	0.022	43	NA	38	380	>500
9	40000	0.022	85	NA	41	410	>500

Matrix 3: Source Decay Constant/Biodegradation

	Input				Output		
			Calculated Constant Input Parameters		Estimated Time to Reach 5 µg/L		
Output	Source Conc. (µg/L)	Decay Constant (1/yr)	Source Mass (kg)	Biodegradation (lambda, 1/yr)	Low End (yrs)	Mid Range (yrs)	High End (yrs)
10	2000	0.18	4.26	0.45	3	33	335
11	20000	0.18	43	0.45	5	46	464
12	40000	0.18	85	0.45	5	50	>500

In conclusion, the output timeframe for Source DK varied based on input parameters. With no decay constant or biodegradation constant the time of remediation would essentially never occur (Matrix 1). Reducing the source concentration by an order of magnitude also did not substantially reduce the time of remediation (compare outputs 4-6). The decay constant appeared to be the most sensitive to the output timeframe (compare Matrices 2a and 2b, the average number of years increased by an order of magnitude). The final matrix scenario, which utilized decay and biodegradation constants, resulted in the shortest timeframe of remediation with a mid range of 33 to 50 years.

Limitations to the model for Tier 2 were shown in Matrix 2b and 3 outputs. By increasing the source groundwater concentration, the source mass would most be assumed to increase for a given site. The source mass concentration contains 3 constituents 1) free-phase or residual NAPL 2) constituent mass sorbed to aquifer 3) dissolved mass in groundwater in the source zone. These matrices' source decay constants were dependent on the source mass concentration for their calculation. Therefore, the source mass was adjusted in Matrix 2b and 3 to maintain a constant source decay constant. For instance, the 2000 µg/L source groundwater concentration would equate to an estimated 4.26 kg source mass concentration. As described above the source mass is calculated as the sum of 3 constituents, and with only one constituent in consideration, estimations of the site source mass were made. .

Source DK Tier 3 Model

The Tier 3 Model employs a process model to predict a remediation timeframe based on the amount of naturally flowing groundwater required to flush out dissolved-phase and NAPL constituents from a source zone.

Data entry for the Tier 3 Process Model includes:

- Original constituent concentration = 2, 20, and 40 mg/L (3 trials)
- Cleanup level = 0.005 mg/L
- Length of source zone parallel to groundwater flow = 50 ft
- Groundwater seepage velocity = 4.38 ft/yr (taken from SA-17, 2003 SI Report)
- Retardation factor = 2.59 (calculated)

This model was employed in order to determine a remediation timeframe given a groundwater zone without any NAPL or matrix diffusion. It is a simple flushing model, based on one-dimensional advection-dispersion, and used to predict the change in dissolved phase constituents over time. The number of pore volumes required to reach the desired cleanup level is also calculated. A pore volume is the volume of water required to replace water in a unit volume of saturated porous media. The output for this model is shown below.

Source DK Tier 3 Output

Source Conc. (µg/L)	Time to Flush Out Constituents and Reach Desired Cleanup Level (yrs)	# Pore Volumes Required to Reach Desired Cleanup Level
2000	93.7	8.21
20000	121	10.6
40000	129	11.3

Modeling Conclusions

Based on the above described results of the modeling effort, the following conclusions were developed:

- Further source reduction results in limited reduction in long term monitoring requirements of site and no measurable increased protection of human health and the environment.
- Given the SA17 source area is approximately 600 feet from the property boundary, the model results indicate that the source will not cause an offsite groundwater concentrations to exceed GCTLs at any point in the future; and
- Given the current distribution of contaminants at the site (i.e., knowing contaminant concentrations downgradient), no location downgradient of the source area at SA17 is anticipated to yield an offsite exceedance of GCTLs at some point in the future.

SourceDK TIER 2 Box Model

Remediation Timeframe Decision Support System

Air Force Center for Environmental Excellence — *Version 1.0*

Data Input Instructions:

- 115 → 1. *Enter value directly ... or*
- 115 → 2. *Calculate by filling in blue cells. Press Enter, then hit "Calculate" button.*
- 115 → 3. *Value calculated by model. (Do not enter any data.)*

Site Location and I.D.: Orlando NTC, SA-17

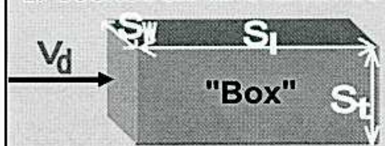
Constituent of Interest: Average Zone B, TCE

1. HYDROGEOLOGY

Darcy Velocity	V_d	1.10E+00	(ft/yr)
		↑ or	
Hydraulic Conductivity	K	1.5E+00	ft/d
Hydraulic Gradient	i	0.002	(ft/ft)

Calculate Vd

2. SOURCE CHARACTERISTICS



Key Assumption:* *Source Represented as Box Model

Average Source Groundwater Concentration at Time = 0	C_{gwo}	40000	ug/L
Source Length	S_l	50	(ft)
Source Width	S_w	50	(ft)
Source Thickness	S_t	30	(ft)
Enter Value for Specific Discharge or Press "Calculate Q" Button	Q	1.6E+03	(ft^3/yr)

Calculate Q

3. SOURCE DECAY CONSTANT

○ Enter Directly — k_s [ ] (1/yr)

↓ or

◉ Calculate Source Decay Constant Using Sections 3A and 3B — k_s 1.8E-01 (1/yr)

3A. SOURCE MASS

Source Mass at Time = 0 — M_o 8.5E+01 (kg)

Select Method for Calculating Source Mass

○ **Method 1:** Enter Source Mass Directly

or

◉ **Method 2:** Simple Volume X Concentration Calculation (Print Method 2)

or

○ **Method 3:** Detailed Volume X Concentration Calculation

or

○ **Method 4:** Estimated From NAPL Relationships

3B. SOURCE ZONE BIODEGRADATION

○ **No Biodegradation**

↓ **or**

Assume Biodegradation Occurs in "Box" in Dissolved Phase Only

◉ **Select Method 1:**

Biodegradation Rate Constant — *lambda* 0.45 *(per yr)*

↓ **or**

○ **Select Method 2:**

Biodegradation Rate Derived From Electron Acceptor By-Product Data.

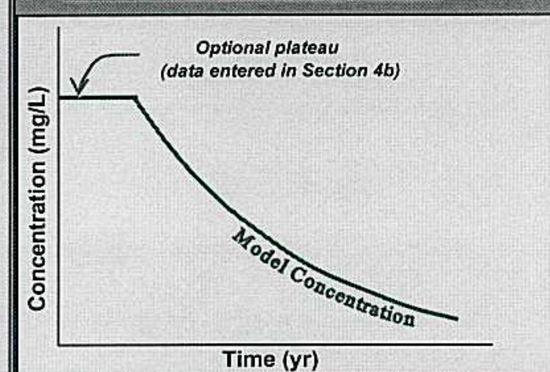
(Applies Only to Petroleum Hydrocarbon Sites)

a) Biodegradation Capacity	BC		(mg/L)
or			
Delta Oxygen	DO		(mg/L)
Delta Nitrate	NO_3		(mg/L)
Observed Ferrous Iron	Fe^{2+}		(mg/L)
Delta Sulfate	SO_4		(mg/L)
Observed Methane	CH_4		(mg/L)

and

b) Percentage of Biodegradation Capacity Applied to This Constituent [ ] (%)

SourceDK OUTPUT SHOWS THIS:



4. TIME FOR OUTPUT

a) Number of Years Over Which to Plot Data — 10 (yr) (Required)

b) Time in Years at Which Decay Starts — [ ] (yr) (Optional)

5. UNCERTAINTY RANGE FOR MASS ESTIMATE

± Factor of 10

6. FIELD DATA FOR COMPARISON

Year From Time = 0 (yr)	0										
Concentration (ug/L)	40000										

7. CHOOSE OUTPUT TO VIEW

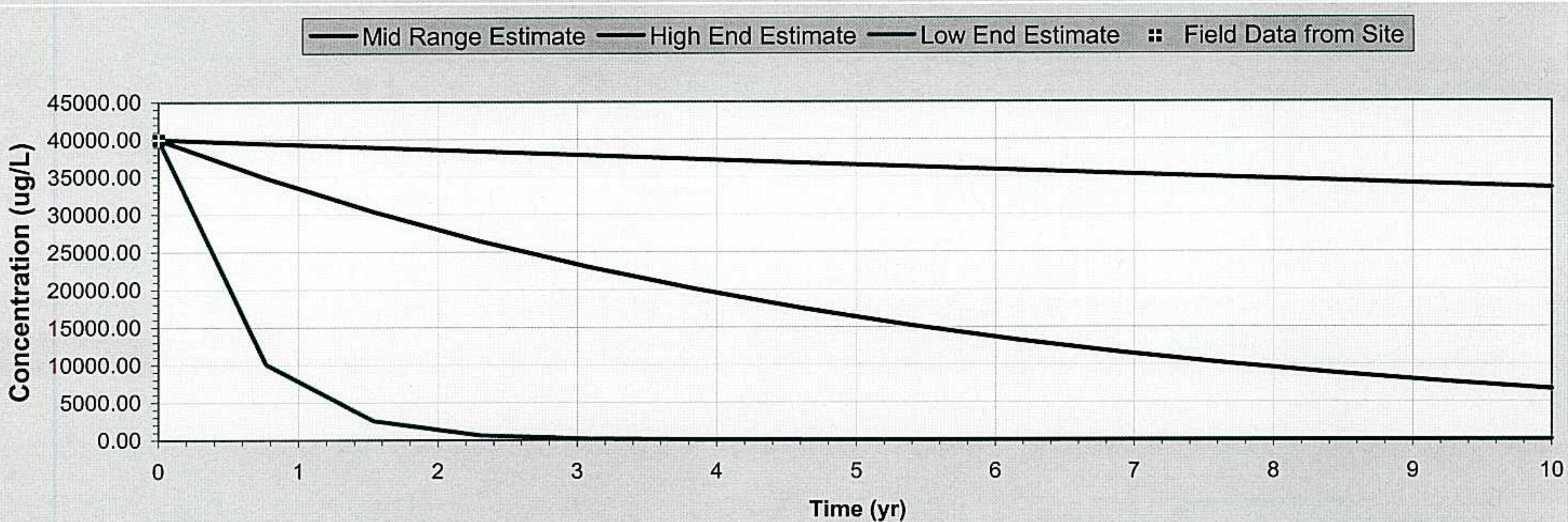
Show Graph | Return to Main Screen | New Site/Clear Screen | Paste Example Data Set | HELP

Site Location and I.D.: Orlando NTC, SA-17
Constituent of Interest: Average Zone B, TCE

SourceDK TIER 2 OUTPUT

TYPE OF MODEL	0.00	0.77	1.54	2.31	3.08	3.85	4.62	5.38	6.15	6.92	7.69	8.46	9.23	10.00
Model Conc. (ug/L)	#######	#######	#######	#######	#######	#######	#######	#######	#######	#######	#######	8749.351	7620.232	6636.828
Actual Conc. (ug/L)	#######													
Mass Discharge (kg/yr)	1.9E+00	1.6E+00	1.4E+00	1.2E+00	1.1E+00	9.3E-01	8.1E-01	7.1E-01	6.2E-01	5.4E-01	4.7E-01	4.1E-01	3.5E-01	3.1E-01

Time (yr)



1. ◉ **Display Concentration Vs. Time Chart**
or
○ Display Source Mass Vs. Time Chart

2. Number of Years Over Which to Plot Graph 10 *(yr)*
(Press "Calculate Current Sheet" button after changing value.)

Log ⟺ Linear

Concentration/Time Mini-Calculator

Time *(yr)* → *(ug/L)* High End Conc Estimate; *(ug/L)* Mid Range Conc Estimate; *(ug/L)* Low End Conc Estimate

Concentration 5.000 *(ug/L)* → >500 *(yr)* High End Time Estimate; 50 *(yr)* Mid Range Time Estimate; 5 *(yr)* Low End Time Estimate

Return To Input

Calculate Current Sheet

HELP

SourceDK

Remediation Timeframe Decision Support System

Air Force Center for Environmental Excellence *Version 1.0*

TIER 3 Process Models

Data Input Instructions:

- 115 → 1. Enter value directly....or
- 115 → 2. Calculate by filling in blue cells. Press Enter, then hit "Calculate"
- 115 → 3. Value calculated by model. (Don't enter any data.)

Site Location:

Constituent:

◉ METHOD 1: DISSOLVED PHASE CONSTITUENTS

Original Constituent Concentration	C_o	40	(mg/L)
Desired Cleanup Level	C_t	0.005	(mg/L)
Length of Source Zone Parallel to Groundwater Flow	L	50	(ft)
Groundwater Seepage Velocity	V_x	4.38	(ft/yr)
Retardation Factor	R	2.59	(-)
		or	
Soil Bulk Density	Rho	1.7	(kg/L)
Partition Coefficient	K_{oc}	130	(L/kg)
Fraction Organic Carbon	f_{oc}	0.0017	(-)
Effective Porosity	n_e	0.25	(-)

Calculate R

Create Graph | HELP

○ METHOD 2: NAPL ZONE CONSTITUENTS

Type of Media

Initial Aqueous-Phase Concentration in Source Zone Under Natural Flow Conditions	C_s		(mg/L)
Desired Cleanup Concentration	C_t		(mg/L)
Density of NAPL Fluid	Rho		(g/mL)
Initial NAPL Saturation in Porous Media	S_o		(%)
Uncertainty in NAPL Saturation	± Factor of		
Natural Groundwater Seepage Velocity	V_s		(ft/yr)
Length of Source Zone Parallel to Groundwater Flow	L		(ft)

Is This a Pumping Scenario?

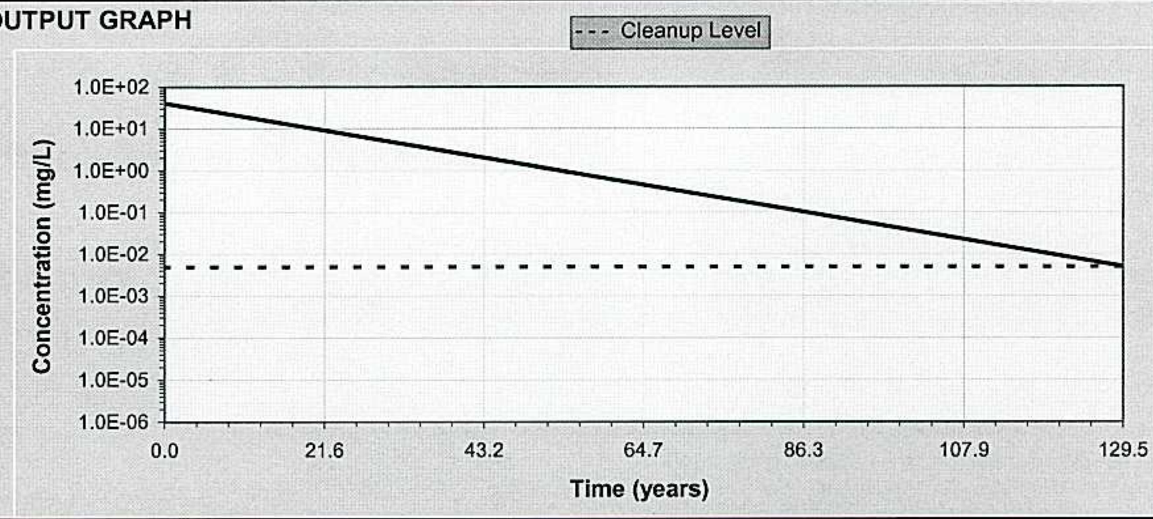
METHOD 2: Continued

What is the Typical Groundwater Seepage Velocity While Pumping? (ft/yr)

Concentration in Produced Groundwater as a Result of Mass Transfer Effects is (mg/L)

Create Graph | HELP

OUTPUT GRAPH



RESULTS

1) The Number of Pore Volumes Required to Reach Desired Cleanup Level: 1.13E+01 (-)

2) Time to Flush Out Constituents and Achieve Desired Cleanup Level: 1.29E+02 (yrs)

Return to Main Screen | New Site/Clear Screen | Paste Example Data Set

Facility Name: NTC Orlando
Site Name: SA-17
Additional Description: TOS Output - 100' POC and 2,000 ug/L source cor

Length: feet
Time: days
Mass: pounds

Hydrogeologic Data and Contaminant Transport Calculations

	Maximum	*Average*	*Minimum*		*Value*
Hydr. Conductivity [ft/d]	3.8	1.5	0.6	*Estimated Plume Length [ft]*	1721.5
Hydraulic Gradient [ft/ft]	0.002	0.002	0.002	*Longitudinal Dispersivity [ft]*	30.48
Total Porosity [-]		0.3		*Dispersivity Ratio [-]*	20.0
Effective Porosity [-]		0.25		*Contaminated Aquifer Thickness [ft]*	20.0
Groundwater Vel. [ft/d]	0.03	0.012	0.005		

Contaminant Data (August 2004)

Well Name	*Distance [ft]*	*TCE [µg/L]*	*cis-DCE [µg/L]*	*Vinyl Chl. [µg/L]*	*Total Chl. Eth. [µg/L]*
D-25	0.0	2000	BD	BD	2000
VD-62	55.0	1000	395	6.9	1401.9
VD-64	100.0	401	233	0.93	634.93
43C	150.0	BD	222	30.9	252.9
20C	275.0	BD	476	820	1296
45C	550.0	BD	114	BD	114

Redox Data (August 2004)

Well Name	*Distance [ft]*	*Oxygen [mg/L]*	*Nitrate [mg/L]*	*Mn(II) [mg/L]*	*Iron(II) [mg/L]*	*Sulfate [mg/L]*	*Sulfide [mg/L]*	*Methane [mg/L]*	*Hydrogen [mg/L]*	*Redox Condition*
D-25	0.0	0.41	NS	0.115	30	128	BD	0.061	NS	Ferrogenic
VD-62	55.0	0.63	BD	0.887	140	737	BD	0.13	NS	Ferrogenic
VD-64	110.0	0.52	BD	1.14	160	158	BD	0.55	BD	Ferrogenic
43C	113.0	0.92	BD	0.0286	5.36	6480	BD	2	BD	SO4/CO2-red.
20C	265.0	0.24	BD	0.0194	2.12	4.51	BD	2.3	2	SO4/CO2-red.
45-C	550.0	6.22	0.03	0.03	2.15	29.4	BD	2.7	2.5	Methanogenic

Sorption Parameters

Fraction Org. Carbon [-]	
Maximum	0.0017
Average	0.0017
Minimum	0.0017

	TCE	*cis-DCE*	*Vinyl Chl.*
Koc [L/kg]	126	24	57
Retardation Factor [-]			
Maximum	2.59	1.3	1.72
Average	2.59	1.3	1.72
Minimum	2.59	1.3	1.72

Attenuation Rates

	Total Chl. Eth.	*TCE*	*cis-DCE*	*Vinyl Chl.*
NAC (Single Zone) [1/ft]	0.0042	0.0159	0.0052	Insuff. Data
Decay Rate [1/d]				
Maximum	0.0001	0.0006	0.0002	
Average	0.0001	0.0002	0.0001	
Minimum	0.000	0.0001	0.000	
NAC (Zone 1) [1/ft]	0.0113	0.0159	.0052 (Est.)	
Decay Rate [1/d]				
Maximum	0.0005	0.0006	0.0002	
Average	0.0002	0.0002	0.0001	
Minimum	0.0001	0.0001	0.000	
NAC (Zone 2) [1/ft]	0.0113 (Est.)	.0159 (Est.	.0052 (Est.)	
Decay Rate [1/d]				
Maximum	0.0005	0.0006	0.0002	
Average	0.0002	0.0002	0.0001	
Minimum	0.0001	0.0001	0.000	
NAC (Zone 3) [1/ft]	0.0042 (Est.)	.0159 (Est.	.0052 (Est.)	
Decay Rate [1/d]				
Maximum	0.0001	0.0006	0.0002	
Average	0.0001	0.0002	0.0001	
Minimum	0.000	0.0001	0.000	

Time of Stabilization(TOS) and Max Source Conc. Calculations

Distance to POC [1 100.0
Estimated Source Wi 30.0

		Source Concentration [µg/L]			TOS [years]		
	RCC [µg/L]	*Well*	*Current*	*Target*	*Maximum*	*Average*	*Minimum*
Total Chl. Eth.	5.0	1	2000	25	117.6	47.0	18.6

Time of Remediation(TOR) Calculations

NAPL Source Widtl 50.0
NAPL Source Lengt 50.0
Contaminated Aquifer Thi 30.0

NAPL Component	*% of NAPL*
TCE	1.00
cis-DCE	0.00

	Oxygen [mg/L]	*Nitrate [mg/L]*	*Mn(IV) [mg/kg]*	*Iron(III) [mg/kg]*	*Sulfate [mg/L]*
Background EA Conc.	0.7	0.0	NS	100.0	96.7

	Average	*+/- %*
NAPL Mass [lb]	93.0	50

	Plan 1	*Plan 2*	*Plan 3*
% NAPL Removed	0	25	50

Maximum Time of Analysis [yr] 100

	SCC [µg/L]
Total Chl. Eth.	5.0

	NAPL Mass (TCE) [lb]	Source Removal Plan *Plan 1* *0% Rem'c*	*Plan 2* *25% Rem'*	*Plan 3* *50% Rem'd*
	139.5	61.1	60.5	59.9
TCE	93.0	60.5	60.2	59.9
	46.5	59.6	59.6	59.6

Attachment B

This Attachment contains the following information:

Attachment B-1: Basis and Level of Accuracy of Estimate
Attachment B-2: Costs for Alternatives 1, 2A, and 2B
Attachment B-3: Technical Input Received from Solutions IES
Attachment B-4: Sketches of Well Configurations for Alternatives 2A and 2B

Attachment B-1 Basis and Level of Accuracy of Estimate

All cost estimates were based on our understanding of the site and current market conditions, as of February 2005. The basis of estimate for each alternative is presented in the discussion below.

Basis of estimate for Alternative 1

The basis of this estimate was the JV-II cost estimate submitted March 22, 2004 to EFD South for implementing the excavation alternative. The estimate was revisited to check key components of the estimate (e.g., excavation quantities, sheet piling costs, soils treatment). This estimate has a level of accuracy of +15/-10% for costs presented as capital.

The main component of this estimate considered to be price - sensitive is the cost of steel for sheet-piling. There is an ample supply of equipment and labor to construct and operate the system and with the exception of price fluctuations of steel, none of the other system components consist of materials that are typically considered volatile with respect to costs. This estimate is classified as a definitive estimate.

Bases of Estimates for Alternatives 2A and 2B

The general basis of the cost estimate for Alternatives 2A and 2B has been established by incorporating the various elements of engineering and construction involved in implementing similar systems, and CH2MHill's experience operating several similar systems. The major elements involved in the implementation of these alternatives is well installation, injection of EOS, injection and recirculation of water, equipment and materials, and the associated labor for engineering, oversight and field implementation.

The major components of the cost estimate for these alternatives include the calculation of the amount of EOS required to treat the estimated mass of contamination within the TTZ, well installation, EOS injection and groundwater recirculation costs. Based on the aquifer characteristics and the quantity of EOS required, the number of injection wells was determined and the associated costs of well installation were arrived at from price quotations from drillers. The cost of injection of the EOS into the subsurface was based on a price quotation from Solutions-IES, Inc, of Raleigh, NC, who is the primary vendor in the market for the implementation of EOS injections. This price quotation is attached

to this cost estimate as Attachment B. Additionally, the costs of equipment required for recirculation (pumps and piping), rental of storage tanks for temporary storage of extracted groundwater, mixing with EOS and reinjection into the subsurface are also included in the price quotation from Solutions-IES, Inc.
The main difference between the cost estimates for Alternatives 2A and 2B is that in the cost estimate for Alternative 2B, the costs of recirculation of groundwater are not included. If necessary, the use of DPT push-points, in lieu of injection wells, could be evaluated in the remedial design phase of Alternative 2B.

The estimates for Alternatives 2A and 2B have a level of accuracy of +50/-30% for costs presented as capital cost. No O&M costs are included in these alternatives, since the post-treatment monitoring will be performed outside the injection effort. This estimate is classified as a conceptual design estimate.
The most market sensitive component of these estimates is the cost of emulsified edible oil substrate (EOS) . However, this material is relatively inexpensive on a per pound basis compared to other injectates, and barring any significant changes in costs, price fluctuations of this material would not significantly impact the cost estimate. Aside from this factor, all other cost factors associated with this alternative are relatively stable and easily available.

A detailed draft quote for EOS injection implementation from Solutions-IES, Inc., the leading subcontractor implementing the EOS injection, has been included in Attachment B-3 for reference. Relevant elements of this quote have been incorporated into the cost estimates for Alternatives 2A and 2B

Attachment B-2: Costs for Alternatives 1, 2A, and 2B

COST ESTIMATE OF CORRECTIVE ACTION OPTIONS
SA17 Source Reduction Alternatives

Site:	Former Naval Training Center, Orlando - Study Area 17	**Base Year:**	2005
Location:	Orlando, Florida	**Date:**	February 2005
Phase:	SA17 Remediation		

	Alternative 1 **Soil Excavation In the Treatment Zone**	Alternative 2 **Enhanced Bioremediation with EOS using Recirculation**	Alternative 3 **Enhanced Bioremediation with EOS using Inject and Chase Method**	
Total Project Duration (Years)	1	1	1	
Total Capital Cost	$1,193,000	$446,000	$394,000	
Total Present Valve of Alternative	**$1,193,000**	**$446,000**	**$394,000**	
		One Injection Event	One Injection Event	
		Baseline Monitoring only	Baseline Monitoring only	

Disclaimer: The information in this cost estimate is based on the best available information regarding the anticipated scope of the remedial alternatives. Changes in the cost elementsof upto +/-50% are likely to occur as a result of new information and data collected and potential revisions in the design assumptions

Alternative 1
SA17 Excavation

COST ESTIMATE SUMMARY

Site: Orlando Naval Training Center - SA17
Location: Orlando, Florida
Phase: SA17 Remediation
Base Year: 2005

Description: Excavation of the Target Treatment Zone to a depth of 50 ft bgs with a footprint of 50 ft width x 50 ft length
Backfill for final grade and restore site vegetation

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
STARTUP					
Mobilization/Demobillization	1	EA	$30,855	$30,855	JVII- Cost Estimate Mar'04
Surface Grading	1.0	LS	$500	$500	350 ft Disturbed Rectangle
SUBTOTAL				**$31,355**	
SHEETING AND SHORING					
Drive Sheeting for Retaining Cell	11,435	sq ft	$49.83	$569,845	Source: Hayward Baker 56 foot diameter cell with 65 foot deep sheeting
Pull Sheeting from Retaining Cell	11,435	sq ft	($1.67)	($19,053)	Cost of pulling plus credit for return of sheet pile
Waler	1	sq ft	$75,286	$75,286	Ring beam
SUBTOTAL				**$626,100**	
EARTHWORK					
Excavate to 50 foot depth	4,561	cy	$13.58	$61,921	JVII- Cost Estimate Mar'04
Backfill	$ 7,000	ls	$7,000.00	$7,000	JVII- Cost Estimate Mar'04
Grass for Erosion Control	62,500	sf	$0.15	$9,375	JVII- Cost Estimate Mar'04
SUBTOTAL				**$78,296**	
TREATMENT					
Treat Excavated Soil	5,108	ton	$36	$182,825	JVII- Cost Estimate Mar'04
Residual Waste Management	250	cy	$68.50	$17,125	JVII- Cost Estimate Mar'04
Add Chemical to Open Excavation	$12,500	LS	$1.23	$15,428	JVII- Cost Estimate Mar'04
Treatment confirmation sampling	$20	ea	$154.28	$3,086	JVII- Cost Estimate Mar'04
SUBTOTAL				**$218,462**	

Alternative 1
SA17 Excavation

COST ESTIMATE SUMMARY

Site: Orlando Naval Training Center - SA17
Location: Orlando, Florida
Phase: SA17 Remediation
Base Year: 2005

Description: Excavation of the Target Treatment Zone to a depth of 50 ft bgs with a footprint of 50 ft width x 50 ft length
Backfill for final grade and restore site vegetation

IMPLEMENTATION COSTS					
Engineering and Permitting	8	%	$918,832	$73,507	JVII- Cost Estimate Mar'04
Project Management and Work Plan Preparation	8	%	$918,832	$73,507	JVII- Cost Estimate Mar'04
Field Labor and Field Office Support During Construction	10	%	$918,832	$91,883	JVII- Cost Estimate Mar'04
Travel Costs	5	%	$918,832	$45,942	
SUBTOTAL				**$238,896**	
TOTAL CAPITAL COST				**$1,193,000**	

ANNUAL OPERATING COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES

PRESENT VALUE ANALYSIS - 0 YEARS

Discount Rate = 7%

End Year	COST TYPE	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR (7%)	PRESENT VALUE	NOTES
0	CAPITAL COST	$1,193,000	$1,193,000	1.000	$1,193,000	
0	ANNUAL O&M COST	$0	$0	0.000	$0	
		$1,193,000			$1,193,000	
	TOTAL PRESENT VALUE OF ALTERNATIVE				**$1,193,000**	

SOURCE INFORMATION

JVII-Cost Estimate March 2004, which includes subcontractor costs based on bids.
Subcontractor prices subject to change due to market variations since March 2004.

EOS Remediation, Inc.

Emulsified Edible Oil Source Design Software
Beta Version 1.0
www.eosremediation.com

Site Name:	SA 17, Former Naval Training Center, Orlando.
Location:	Orlando, FL
Project No.:	

Section A: Treatment Area Dimensions

Width of source area perpendicular to groundwater flow	50	ft	15.2	m
Length of source area parallel to groundwater flow	50	ft	15.2	m
Minimum depth to contamination	35	ft	10.7	m
Maximum depth of contamination	55	ft	16.8	m
Treatment thickness	20	ft	6.1	m
Treatment zone cross-sectional area	1,000	ft^2	93	m^2
Treatment zone volume	50,000	ft^3	1,416	m^2
Treatment zone groundwater volume (volume x effective porosity)	63,580	gallons	240,693	L

Groundwater Flow Rate/ Site Data

Soil Characteristics				
Nominal Soil Type (enter clay, silt, silty sand, sand, or gravel)	silty sand			
Hydraulic Characteristics				
Total Porosity (accept default or enter *n*)	0.28	(decimal)		
Effective Porosity (accept default or n_e)	0.17	(decimal)		
Hydraulic Conductivity (accept default or enter *K*)	15	ft/day	5.3E-03	cm/sec
Hydraulic Gradient (accept default or enter *i*)	0.005	ft/ft		
Seepage velocity (V_x)	0.441	ft/day	0.1345	m/day
Groundwater flowrate through treatment zone (Q)	561	gallons/day	2124	L/day

Design Lifespan For One Application	5	year(s)	typical values 5 to 10 years	
Total groundwater volume treated over design life	1,087,405	gallons	4,116,562	L

Electron Acceptors

Inputs		Typical Value	GW Conc. (mg/L)	MW (g/mole)	e^- equiv./ mole	Stoichmetry *Contaminant/H_2 (wt/wt H_2)*	Hydrogen Demand *(g H_2)*
Dissolved Oxygen (DO)	from MNA04.xls	0 to 8	0.3	32.0	4	7.94	155.5964252
Nitrate Nitrogen (NO_3^- - N)	from MNA04.xls	1 to 10	0.06	62.0	5	12.30	20.07461867
Sulfate (SO_4^{2-})	from MNA04.xls	10 to 500	89	96.1	8	11.91	30753.90886
Tetrachloroethene (PCE), C_2Cl_4				165.8	8	20.57	
Trichloroethene (TCE), C_2HCl_3			20	131.4	6	21.73	3789.436468
cis-1,2-dichloroethene (c-DCE), $C_2H_2Cl_2$			1	96.9	4	24.05	171.1953693
Vinyl Chloride (VC), C_2H_3Cl			0.3	62.5	2	31.00	39.83201964
Carbon tetrachloride, CCl_4				153.8	8	19.08	
Chloroform, $CHCl_3$				119.4	6	19.74	
sym- tetrachloroethane, $C_2H_2Cl_4$				167.8	8	20.82	
1,1,1-Trichloroethane (TCA), CH_3CCl_3				133.4	6	22.06	
1,1-Dichloroethane (DCA), CH_2CHCl_2				99.0	4	24.55	
Chloroethane, C_2H_5Cl				64.9	2	32.18	
Perchlorate, ClO_4^-				99.4	8	12.33	
Hexavalent Chromium, Cr[VI]				52.0	3	17.20	
User added							
User added							
User added							

Additional Hydrogen Demand and Carbon Losses

Generation (Potential Amount Formed)	Typical Value	GW Conc. (mg/L)	MW (g/mole)	e^- equiv./ mole	Stoichmetry *Contaminant/H_2 (wt/wt H_2)*	Hydrogen Demand *(g H_2)*	DOC Released *(moles)*
Estimated Amount of $Fe2^+$ Formed	10 to 100	50	55.8	1	55.41	3714.819957	
Estimated Amount of Manganese (Mn^{2+}) Formed		5	54.9	2	27.25	755.2299701	
Estimated Amount of CH_4 Formed	5 to 20	10	16.0	8	1.99	20690.32406	
Target Amount of DOC to Release	60 to 100	100	12.0				34273.26

Note:
Calculations assume:
1.) all reactions go to completion during passage through emulsified edible oil treated zone; and,
2.) perfect reaction stoichiometry.

EOS® Requirement Calculations Based on Hydrogen Demand and Carbon Losses

Stoichiometric Hydrogen Demand	132	pounds
DOC Released	1,177	pounds

EOS® Requirement Based on Hydrogen Demand and Carbon Loss

6 drums

Substrate Requirement Calculations Based on Adsorptive Capacity of Soil

Soil Characteristics

Nominal soil type (enter silt, silty sand, or sand)	silty sand	
Density of soil (accept default or enter site specific value)	125	lbs / ft3
Effective Thickness (typically less than 40%)	0.25	
Weight of sediment to be treated	1,562,500	lbs
Adsorptive Capacity of Soil (accept default or enter site specific value)	0.002	lbs EOS® / lbs soil

Aquifer "Sorption" Capacity[1]
- Fine sand with some clay 0.001 to 0.002 lbs EOS® / lbs soil
- Sand with higher silt/clay content 0..002 to 0.004 lbs EOS® / lbs soil

[1]Default values provided based on laboratory studies completed by NCSU

EOS® Requirement Based on Adsorptive Capacity of Soil

8 drums

Suggested Quantity of EOS® for Your Project

8 drums

EOS Remediation, Inc.

Emulsified Edible Oil Source Design Software
Beta Version 1.0
www.eosremediation.com

Site Name:	SA 17, Former Naval Training Center, Orlando.
Location:	Orlando, FL
Project No.:	

Section A: Treatment Area Dimensions

Width of source area perpendicular to groundwater flow	50	ft	15.2	m
Length of source area parallel to groundwater flow	50	ft	15.2	m
Minimum depth to contamination	20	ft	6.1	m
Maximum depth of contamination	35	ft	10.7	m
Treatment thickness	15	ft	4.6	m
Treatment zone cross-sectional area	750	ft^2	70	m^2
Treatment zone volume	37,500	ft^3	1,062	m^2
Treatment zone groundwater volume (volume x effective porosity)	47,685	gallons	180,520	L

Groundwater Flow Rate/ Site Data

Soil Characteristics				
Nominal Soil Type (enter clay, silt, silty sand, sand, or gravel)	silty sand			
Hydraulic Characteristics				
Total Porosity (accept default or enter *n*)	0.28	(decimal)		
Effective Porosity (accept default or n_e)	0.17	(decimal)		
Hydraulic Conductivity (accept default or enter *K*)	15	ft/day	5.3E-03	cm/sec
Hydraulic Gradient (accept default or enter *i*)	0.005	ft/ft		
Seepage velocity (V_x)	0.441	ft/day	0.1345	m/day
Groundwater flowrate through treatment zone (Q)	421	gallons/day	1593	L/day

Design Lifespan For One Application	5	year(s)	typical values 5 to 10 years	
Total groundwater volume treated over design life	815,554	gallons	3,087,421	L

Electron Acceptors

Inputs		Typical Value	GW Conc. (mg/L)	MW (g/mole)	e^- equiv./ mole	Stoichmetry *Contaminant/H_2 (wt/wt H_2)*	Hydrogen Demand *(g H_2)*
Dissolved Oxygen (DO)	from MNA04.xls	0 to 8	0.3	32.0	4	7.94	116.6973189
Nitrate Nitrogen (NO_3^- - N)	from MNA04.xls	1 to 10	0.06	62.0	5	12.30	15.055964
Sulfate (SO_4^{2-})	from MNA04.xls	10 to 500	89	96.1	8	11.91	23065.43165
Tetrachloroethene (PCE), C_2Cl_4				165.8	8	20.57	
Trichloroethene (TCE), C_2HCl_3			20	131.4	6	21.73	2842.077351
cis-1,2-dichloroethene (c-DCE), $C_2H_2Cl_2$			1	96.9	4	24.05	128.3965269
Vinyl Chloride (VC), C_2H_3Cl			0.3	62.5	2	31.00	29.87401473
Carbon tetrachloride, CCl_4				153.8	8	19.08	
Chloroform, $CHCl_3$				119.4	6	19.74	
sym- tetrachloroethane, $C_2H_2Cl_4$				167.8	8	20.82	
1,1,1-Trichloroethane (TCA), CH_3CCl_3				133.4	6	22.06	
1,1-Dichloroethane (DCA), CH_2CHCl_2				99.0	4	24.55	
Chloroethane, C_2H_5Cl				64.9	2	32.18	
Perchlorate, ClO_4^-				99.4	8	12.33	
Hexavalent Chromium, Cr[VI]				52.0	3	17.20	
User added							
User added							
User added							

Additional Hydrogen Demand and Carbon Losses

Generation (Potential Amount Formed)	Typical Value	GW Conc. (mg/L)	MW (g/mole)	e^- equiv./ mole	Stoichmetry *Contaminant/H_2 (wt/wt H_2)*	Hydrogen Demand *(g H_2)*	DOC Released *(moles)*
Estimated Amount of $Fe2^+$ Formed	10 to 100	50	55.8	1	55.41	2786.114968	
Estimated Amount of Manganese (Mn^{2+}) Formed		5	54.9	2	27.25	566.4224776	
Estimated Amount of CH_4 Formed	5 to 20	10	16.0	8	1.99	15517.74305	
Target Amount of DOC to Release	60 to 100	100	12.0				25704.95

Note:
Calculations assume:
1.) all reactions go to completion during passage through emulsified edible oil treated zone; and,
2.) perfect reaction stoichiometry.

EOS® Requirement Calculations Based on Hydrogen Demand and Carbon Losses

Stoichiometric Hydrogen Demand	99	pounds
DOC Released	883	pounds

EOS® Requirement Based on Hydrogen Demand and Carbon Loss

5 drums

Substrate Requirement Calculations Based on Adsorptive Capacity of Soil

Soil Characteristics

Nominal soil type (enter silt, silty sand, or sand)	silty sand	
Density of soil (accept default or enter site specific value)	125	lbs / ft3
Effective Thickness (typically less than 40%)	0.25	
Weight of sediment to be treated	1,171,875	lbs
Adsorptive Capacity of Soil (accept default or enter site specific value)	0.002	lbs EOS® / lbs soil

Aquifer "Sorption" Capacity[1]
- Fine sand with some clay 0.001 to 0.002 lbs EOS® / lbs soil
- Sand with higher silt/clay content 0..002 to 0.004 lbs EOS® / lbs soil

[1]Default values provided based on laboratory studies completed by NCSU

EOS® Requirement Based on Adsorptive Capacity of Soil

6 drums

Suggested Quantity of EOS® for Your Project

6 drums

Emulsified Edible Oil Source Design Software
Beta Version 1.0
www.eosremediation.com

EOS Remediation, Inc.

Site Name:	SA 17, Former Naval Training Center, Orlando.
Location:	Orlando, FL
Project No.:	

Section A: Treatment Area Dimensions

Width of source area perpendicular to groundwater flow	50	ft	15.2	m
Length of source area parallel to groundwater flow	50	ft	15.2	m
Minimum depth to contamination	5	ft	1.5	m
Maximum depth of contamination	20	ft	6.1	m
Treatment thickness	15	ft	4.6	m
Treatment zone cross-sectional area	750	ft^2	70	m^2
Treatment zone volume	37,500	ft^3	1,062	m^2
Treatment zone groundwater volume (volume x effective porosity)	47,685	gallons	180,520	L

Groundwater Flow Rate/ Site Data

Soil Characteristics				
Nominal Soil Type (enter clay, silt, silty sand, sand, or gravel)	silty sand			
Hydraulic Characteristics				
Total Porosity (accept default or enter *n*)	0.28	(decimal)		
Effective Porosity (accept default or n_e)	0.17	(decimal)		
Hydraulic Conductivity (accept default or enter *K*)	15	ft/day	5.3E-03	cm/sec
Hydraulic Gradient (accept default or enter *i*)	0.005	ft/ft		
Seepage velocity (V_x)	0.441	ft/day	0.1345	m/day
Groundwater flowrate through treatment zone (Q)	421	gallons/day	1593	L/day

Design Lifespan For One Application	5	year(s)	typical values 5 to 10 years	
Total groundwater volume treated over design life	815,554	gallons	3,087,421	L

Electron Acceptors

Inputs		Typical Value	GW Conc. (mg/L)	MW (g/mole)	e^- equiv./ mole	Stoichmetry *Contaminant/H_2 (wt/wt H_2)*	Hydrogen Demand *(g H_2)*
Dissolved Oxygen (DO)	from MNA04.xls	0 to 8	0.3	32.0	4	7.94	116.6973189
Nitrate Nitrogen (NO_3^- - N)	from MNA04.xls	1 to 10	0.06	62.0	5	12.30	15.055964
Sulfate (SO_4^{2-})	from MNA04.xls	10 to 500	89	96.1	8	11.91	23065.43165
Tetrachloroethene (PCE), C_2Cl_4				165.8	8	20.57	
Trichloroethene (TCE), C_2HCl_3			20	131.4	6	21.73	2842.077351
cis-1,2-dichloroethene (c-DCE), $C_2H_2Cl_2$			1	96.9	4	24.05	128.3965269
Vinyl Chloride (VC), C_2H_3Cl			0.3	62.5	2	31.00	29.87401473
Carbon tetrachloride, CCl_4				153.8	8	19.08	
Chloroform, $CHCl_3$				119.4	6	19.74	
sym- tetrachloroethane, $C_2H_2Cl_4$				167.8	8	20.82	
1,1,1-Trichloroethane (TCA), CH_3CCl_3				133.4	6	22.06	
1,1-Dichloroethane (DCA), CH_2CHCl_2				99.0	4	24.55	
Chloroethane, C_2H_5Cl				64.9	2	32.18	
Perchlorate, ClO_4^-				99.4	8	12.33	
Hexavalent Chromium, Cr[VI]				52.0	3	17.20	
User added							
User added							
User added							

Additional Hydrogen Demand and Carbon Losses

Generation (Potential Amount Formed)	Typical Value	GW Conc. (mg/L)	MW (g/mole)	e^- equiv./ mole	Stoichmetry *Contaminant/H_2 (wt/wt H_2)*	Hydrogen Demand *(g H_2)*	DOC Released *(moles)*
Estimated Amount of $Fe2^+$ Formed	10 to 100	50	55.8	1	55.41	2786.114968	
Estimated Amount of Manganese (Mn^{2+}) Formed		5	54.9	2	27.25	566.4224776	
Estimated Amount of CH_4 Formed	5 to 20	10	16.0	8	1.99	15517.74305	
Target Amount of DOC to Release	60 to 100	100	12.0				25704.95

Note:
Calculations assume:
1.) all reactions go to completion during passage through emulsified edible oil treated zone; and,
2.) perfect reaction stoichiometry.

EOS® Requirement Calculations Based on Hydrogen Demand and Carbon Losses

Stoichiometric Hydrogen Demand	99	pounds
DOC Released	883	pounds

EOS® Requirement Based on Hydrogen Demand and Carbon Loss

5 drums

Substrate Requirement Calculations Based on Adsorptive Capacity of Soil

Soil Characteristics

Nominal soil type (enter silt, silty sand, or sand)	silty sand	
Density of soil (accept default or enter site specific value)	125	lbs / ft3
Effective Thickness (typically less than 40%)	0.25	
Weight of sediment to be treated	1,171,875	lbs
Adsorptive Capacity of Soil (accept default or enter site specific value)	0.002	lbs EOS® / lbs soil

Aquifer "Sorption" Capacity[1]
- Fine sand with some clay 0.001 to 0.002 lbs EOS® / lbs soil
- Sand with higher silt/clay content 0..002 to 0.004 lbs EOS® / lbs soil

[1]Default values provided based on laboratory studies completed by NCSU

EOS® Requirement Based on Adsorptive Capacity of Soil

6 drums

Suggested Quantity of EOS® for Your Project **6** drums

Alternative 2 **COST ESTIMATE SUMMARY**

Enhanced In Situ Biodegradation Using Emulsified Edible Oil

SA17- EOS Injection and Recirculation of Treated Groundwater with Treatment Monitoring Downgradient

Site: Orlando Naval Training Center - SA17
Location: Orlando, Florida
Phase: SA17 Remediation
Base Year: 2005

Description: Enhanced in-situ biodegradation using emulsified edible oil in the shallow and deep intervals of the surficial aquifer.

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
PRE-INJECTION ACTIVITIES					
Injection and Monitoring Well Installation	1	EA	$104,231	$104,231	See Extraction and Injection Well Installation Cost Detail Sheet; extraction well costs excluded
Survey	1	LS	$1,000	$1,000	
Mobilization and Prep Work					
Security Fencing, Signs, Traffic Control, and Utility Location	1	LS	$3,500	$3,500	
Baseline Groundwater Sample Collection Event	1	EA	$25,300	$25,300	Sample 15 Proposed Monitoring Wells
Procurement of fresh water from utility co.	1	LS	$6,000	$6,000	of trenching, piping, fittings and labor + water bill
Electrical Hookup	1	LS	$61,710	$61,710	CH2M HILL Estimate
Electrcity Usage	1	LS	$3,000	$3,000	CH2M HILL estimate
Transportation and Disposal of Asphalt (non-haz waste)	20	tons	$68.50	$1,370	CH2M HILL Estimate
SUBTOTAL				**$206,110**	
EMULSIFIED EDIBLE OIL (EOS) INJECTION					
Pressurized Injection System					
Plans, Mob / Demob, Reports	1	EA	$11,108	$11,108	
Field Implementation	1	LS	$59,488	$59,488	Solutions-IES Inc.estimate Jan '05
Material Costs - Emulsified Edible Oil (EOS)	20	DRUM	$1,037	$20,735	EOS Remediation Systems telecon January 2005
Shipping - Emulsified Edible Oil	1	LOAD	$800	$800	EOS Remediation Systems telecon January 2005
Equipment and Material	1	LS	$2,468	$2,468	
SUBCONTRACTOR SUBTOTAL				**$94,599**	
LABOR					
Project Managemen,Plans and Reports	8	%	$300,710	$24,057	
Engineering (Design and Permitting)	8	%	$300,710	$24,057	
Field Oversight	10	%	$300,710	$30,071	
Travel Costs	5	%	$300,710	$15,035	
SUBTOTAL				**$93,220**	
TOTAL CAPITAL COST				**$393,930**	

Alternative 2 **COST ESTIMATE SUMMARY**

Enhanced In Situ Biodegradation Using Emulsified Edible Oil

SA17- EOS Injection and Recirculation of Treated Groundwater with Treatment Monitoring Downgradient

Site: Orlando Naval Training Center - SA17
Location: Orlando, Florida
Phase: SA17 Remediation
Base Year: 2005

Description: Enhanced in-situ biodegradation using emulsified edible oil in the shallow and deep intervals of the surficial aquifer.

PRESENT VALUE ANALYSIS - 8 YEARS

Discount Rate = 7%

End Year	COST TYPE	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR (7%)	PRESENT VALUE	NOTES
0	CAPITAL COST - 1st injection event	$393,930	$393,930	1.000	$393,930	
	TOTAL PRESENT VALUE OF ALTERNATIVE				**$394,000**	

SOURCE INFORMATION

Alternative 2 **COST ESTIMATE SUMMARY**

Enhanced In Situ Biodegradation Using Emulsified Edible Oil

SA17- EOS Injection and Recirculation of Treated Groundwater with Treatment Monitoring Downgradient

Site: Orlando Naval Training Center - SA17
Location: Orlando, Florida
Phase: SA17 Remediation
Base Year: 2005

Description: Enhanced in-situ biodegradation using emulsified edible oil in the shallow, intermediat and deep intervals of the surficial aquifer.

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
PRE-INJECTION ACTIVITIES					
Injection, Extraction and Monitoring Well Installation	1	EA	$132,000	$132,000	See Extraction and Injection Well Installation Cost Detail Sheet
Survey	1	LS	$1,000	$1,000	
Mobilization and Prep Work					
Security Fencing, Signs, Traffic Control, and Utility Location	1	LS	$3,500	$3,500	
Trenching for underground piping	1	LS	$3,000	$3,000	CH2M HILL Estim. approx 350 LF to 2 ft bgs-incl labor & equip
2"- Sched 80 PVC Piping & fittings for conveyance of EOS and extraction water	400	LF	$1.50	$600	USPlastics Corp web quote
Baseline Groundwater Sample Collection Event	1	EA	$25,300	$25,300	Sample 15 Proposed Monitoring Wells
Frac Tank for Temporary Storage of Extracted Water and Fresh Water	1	MO	$2,172	$2,172	CH2MHll historic pricing-17,000 gal capacity/3 month rental @ $2,172/month
Procurement of fresh water from utility co.	1	LS	$6,000	$6,000	CH2M HILL Estim. approx 600 LF of trenching, piping, fittings and labor + water bill
Electrical Hookup	1	LS	$61,710	$61,710	CH2M HILL Estimate
Electrcity Usage	1	LS	$3,000	$3,000	CH2M HILL estimate
Transportation and Disposal of Asphalt (non-haz waste)	20	tons	$68.50	$1,370	CH2M HILL Estimate
SUBTOTAL				**$239,652**	
EMULSIFIED EDIBLE OIL (EOS) INJECTION					
Pressurized Injection System					
Plans, Mob / Demob, Reports	1	EA	$11,108	$11,108	
Field Implementation	1	LS	$65,659	$65,659	Solutions-IES Inc.estimate Jan '05
Material Costs - Emulsified Edible Oil (EOS)	20	DRUM	$1,037	$20,735	EOS Remediation Systems telecon January 2005
Shipping - Emulsified Edible Oil	1	LOAD	$800	$800	EOS Remediation Systems telecon January 2005
Equipment and Material	1	LS	$2,468	$2,468	
SUBCONTRACTOR SUBTOTAL				**$100,770**	
LABOR					
Project Managemen,Plans and Reports	8	%	$340,422	$27,234	
Engineering (Design and Permitting)	8	%	$340,422	$27,234	
Field Oversight	10	%	$340,422	$34,042	
Travel Costs	5	%	$340,422	$17,021	
SUBTOTAL				**$105,531**	
TOTAL CAPITAL COST				**$445,953**	

Alternative 2 **COST ESTIMATE SUMMARY**

Enhanced In Situ Biodegradation Using Emulsified Edible Oil

SA17- EOS Injection and Recirculation of Treated Groundwater with Treatment Monitoring Downgradient

Site: Orlando Naval Training Center - SA17
Location: Orlando, Florida
Phase: SA17 Remediation
Base Year: 2005

Description: Enhanced in-situ biodegradation using emulsified edible oil in the shallow, intermediat and deep intervals of the surficial aquifer.

PRESENT VALUE ANALYSIS - 8 YEARS

Discount Rate = 7%

End Year	COST TYPE	TOTAL COST	TOTAL COST PER YEAR	DISCOUNT FACTOR (7%)	PRESENT VALUE	NOTES
1	CAPITAL COST	$445,953	$445,953	1.000	$445,953	
	TOTAL PRESENT VALUE OF ALTERNATIVE				**$446,000**	

SOURCE INFORMATION

Alternative: **Alternative 2**

Element: **Injection and Extraction Well Installation in the Shallow, Intermediate and Deep Zones**

Site: Orlando Naval Training Center - SA17
Location: Orlando, Florida
Phase: SA17 Remediation
Base Year: 2005

WORK STATEMENT

Installation of EOS injection wells, extraction wells and monitoring wells to evaluate EOS performance.

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
Monitoring Well Installation - HSA Drilling (incl all drilling sub costs)	300	LF	$72.82	$21,845	Partridge - 2005 Assume combination of existing and 8 new monitoring wells
Injection Well Installation - HSA Drilling (incl. all drilling sub costs)	525	LF	$72.82	$38,229	Partridge - 2005 4 Inj Wells each in the shallow and interm. zones; 4 pairs of inj wells in deep zone total of 16 inj wells with 5 ft screens
Extraction Well Installation - HSA Drilling (incl. all drilling costs)	250	LF	$88.86	$22,216	Partridge - 2005 Two 4-inch extraction wells ea. in the shallow and interm. zones; 2 pairs in deep zone total 8 inj wells with 5 ft screens
Waste Management	1	LS	$18,513	$18,513	CH2M HILL and Driller Estimate-2005
SUBTOTAL				**$100,803**	

Project Management	8%	of	$100,803	$8,064	
Technical Support	8%	of	$100,803	$8,064	
Construction Management	10%	of	$100,803	$10,080	
Travel Costs	5%	of	$100,803	$5,040	
SUBTOTAL				**$31,249**	
TOTAL UNIT COST				**$132,000**	

OPERATIONS AND MAINTENANCE COST

DESCRIPTION	QTY	UNIT	UNIT COST	TOTAL	NOTES
TOTAL ANNUAL O&M COST				**$0**	

Source of Cost Data

1. Sources are as noted in cost table.

Alternative:	**Alternatives 4S**
Element:	**Substrate Injection Duration**

Site:	Orlando Naval Training Center - SA17
Location:	Orlando, Florida
Phase:	SA17 Remediation
Base Year:	2005

WORK STATEMENT

Determination of the number of injection wells required for each injection zone and the amount of time required to inject the EOS substrate and chase volume calculated in the respecitve EOS Calcs sheet.

DIRECT PUSH TECHNOLOGY INJECTION TIME REQUIREMENTS

Shallow Zone

Treatment Area Injection Well Requirements:

Treatement Area:

Length:	50	ft	
Width:	50	ft	
Area:	2,500	sq ft	

Number of Injection Wells Required:

Assumed ROI:	15	ft	
Coverage per injection well:	707	sq ft	
Number of wells required:	4		

Injection Time Requirements:

Treatment area thickness:	15	ft	
Porosity:	0.17		
Treatment area pore water volume:	6,375	cubic ft	
	47,688	gallons	
			From EOS Source
EOS injection volume per injection point	578	gallons	Area Calcs-SZ
Total EOS injection volume:	2,310	gallons	
Chase volume:	6,930	gallons	
(percent pore volume contacted:	19.4%)		
Estimated flow rate per well:	3	gpm	
Number of concurrent injection points:	4		
Hours of injection per day:	8	hrs	
Time to complete injection:	2	days	

Alternative:	**Alternatives 4S**
Element:	**Substrate Injection Duration**

Site:	Orlando Naval Training Center - SA17
Location:	Orlando, Florida
Phase:	SA17 Remediation
Base Year:	2005

WORK STATEMENT

Determination of the number of injection wells required for each injection zone and the amount of time required to inject the EOS substrate and chase volume calculated in the respecitve EOS Calcs sheet.

Intermediate Zone

Treatment Area Injection Well Requirements:

Treatement Area:

Length:	50	ft	
Width:	50	ft	
Area:	2,500	sq ft	

Number of Injection Wells Required:

Assumed ROI:	15	ft	
Coverage per injection well:	707	sq ft	
Number of wells required:	4		

Injection Time Requirements:

Treatment area thickness:	15	ft	
Porosity:	0.17		
Treatment area pore water volume:	6,375	cubic ft	
	47,688	gallons	
EOS injection volume per injection point	578	gallons	From EOS Source Area Calcs-IZ
EOS injection volume:	2,310	gallons	
Chase volume:	6,930	gallons	
(percent pore volume contacted:	19.4%)		
Estimated flow rate per well:	3	gpm	
Number of concurrent injection points:	4		
Hours of injection per day:	8	hrs	
Time to complete injection:	2	days	

Alternative:	**Alternatives 4S**
Element:	**Substrate Injection Duration**

Site:	Orlando Naval Training Center - SA17
Location:	Orlando, Florida
Phase:	SA17 Remediation
Base Year:	2005

WORK STATEMENT

Determination of the number of injection wells required for each injection zone and the amount of time required to inject the EOS substrate and chase volume calculated in the respecitve EOS Calcs sheet.

Deep Zone

Treatment Area Injection Well Requirements:

Treatement Area:

Length:	50	ft	
Width:	50	ft	
Area:	2,500	sq ft	

Number of Injection Wells Required:

Assumed ROI:	15	ft	
Coverage per injection well:	707	sq ft	
Number of injection locations required:	4		

Injection Time Requirements:

Treatment area thickness:	20	ft	
Porosity:	0.17		
Treatment area pore water volume:	8,500	cubic ft	
	63,584	gallons	
EOS injection volume per injection point	385	gallons	From EOS Source Area Calcs-DZ
EOS injection volume:	3,080	gallons	
Chase volume:	9,240	gallons	
(percent pore volume contacted:	19.4%)		
Estimated flow rate per well:	3	gpm	
Number of concurrent injection points:	4		
Hours of injection per day:	8	hrs	
Time to complete injection:	3	days	

Alternative: **Alternatives 4S**

Element: **Sample Collection and Laboratory Costs - Evaluation of Enhanced In Situ Biodegradation Performance**

Site: Orlando Naval Training Center - SA17
Location: Orlando, Florida
Phase: SA17 Remediation
Base Year: 2005

WORK STATEMENT

Costs associated with water sample collection from monitoring wells only for baseline monitoring included. Samples collected to evaluate enhanced bio performance. Unit Costs are per sample per event.

CAPITAL COSTS

DESCRIPTION	QTY	UNIT	COST	TOTAL	NOTES
Equipment & Labor per Event					
Sample Analysis					
VOCs - SW8260 - Level III	15	SAMPLE	$95	$1,425	
Carbon Dioxide - RSK-175	0	SAMPLE	$135	$0	
Nitrate/Nitrite - 352.2 or 300	0	SAMPLE	$50	$0	
Sulfide	15	SAMPLE	$20	$300	
Sulfate	15	SAMPLE	$20	$300	15 Monitoring Wells
Manganese - SW6010B	0	SAMPLE	$20	$0	5 Shallow Zone,
Potassium - SW6010B	0	SAMPLE	$20	$0	5 Intermediate Zone and
Bromide	0	SAMPLE	$20	$0	5 Deep Zone
Alkalinity - SM 2320-B	15	SAMPLE	$15	$225	
Chloride - SW9056	15	SAMPLE	$20	$300	Sulfate/Sulfide, Iron,
Iron - SW6010B	15	SAMPLE	$20	$300	Alkalinity, Chloride -
Iron II - SM3500 - Fe	15	SAMPLE	$20	$300	Semi-Annual Only
Iron III (calculated)	15	SAMPLE	$0	$0	
Total Organic Carbon - SW9060	15	SAMPLE	$25	$375	
Total Dissolved Solids E160.1	0	SAMPLE	$20	$0	
Total Suspended Solids E160.2	0	SAMPLE	$20	$0	
Hexavalent Chromium	0	SAMPLE	$25	$0	
Methane/Ethene/Ethane	15	SAMPLE	$150	$2,250	
Trip Blanks- VOCs	1	SAMPLE	$95	$95	
Dehalococcoides etheneogenes	15	SAMPLE	$275	$4,125	Microbial Insights - August
Volatile Fatty Acids	15	SAMPLE	$100	$1,500	2004
Phospholipid Fatty Acids	15	SAMPLE	$265	$3,975	Semi-Annual Only
QA/QC Samples	2	SAMPLE	$95	$190	VOCs Only
Equipment & Labor					
Sampling Supplies	1	EA	$750	$750	
Groundwater Sampling					Includes YSI 6500 and
Equipment Rental	1	WK	$600	$600	Grunfos Pump
Sample Shipment	1	EA	$400	$400	CH2M HILL Estimate
Labor - Technicians	30	HR	$100	$3,000	1 hr/well, 2 people
SUBTOTAL				**$20,410**	
Data Validation	4	HR	$100	$400	
Data Management	4	HR	$100	$400	
Project Management	5%	of	$20,410	$1,021	
Technical Support	5%	of	$20,410	$1,021	
Construction Management	0%	of	$20,410	$0	
Project Delivery	10%	of	$20,410	$2,041	
Subcontractor General Requirements	5%	of	$20,410	$1,021	
SUBTOTAL				**$4,882**	
TOTAL UNIT COST				**$25,300**	

Alternative: **Alternatives 4S**

Element: **Sample Collection and Laboratory Costs -**

Evaluation of Enhanced In Situ Biodegradation Performance

Site: Orlando Naval Training Center - SA17
Location: Orlando, Florida
Phase: SA17 Remediation
Base Year: 2005

WORK STATEMENT

Costs associated with water sample collection from monitoring wells only for baseline monitoring included. Samples collected to evaluate enhanced bio performance. Unit Costs are per sample per event.

Source of Cost Data

Recent analytical sampling conducted by CH2M HILL on other projects of similar nature.

Attachment B-3: Technical Input Received from Solutions IES

Solutions
Industrial & Environmental Services

3722 Benson Drive ■ Raleigh, NC 27609
(919) 873-1060 ■ Fax (919) 873-1074
www.solutions-ies.com

January 7, 2005

Mr. Sam Naik
CH2MHILL
115 Perimeter Center Plaza NE, Suite 7000
Atlanta, GA 30346-1278

Re.: Proposal for Services
Study Area 17, Naval Training Center
Orlando, Florida
Solutions-IES Proposal No. NC05335P

Dear Mr. Naik:

Solutions Industrial & Environmental Services, Inc. (Solutions-IES) is pleased to provide this proposal to inject an emulsified oil substrate (EOS®) to treat chlorinated solvents in groundwater within Study Area (SA)-17 at the Naval Training Center (NTC) in Orlando, Florida. This proposal summarizes background information regarding the site, outlines our planned approach, and provides a range of estimated costs.

Background

We received copies of site data via e-mail. The data package consisted of a geologic profile from north to south (Figure 1-2) and six concentration maps: TCE-NAPL, TCE, cis-1,2-DCE, trans-1,2-DCE, 1,1-DCE and vinyl chloride where the different wells are shaded according to the contaminant concentration range. The existing monitor wells have been screened within four zones: Zone A is from 5 to 15 feet below land surface (bls), Zone B is from 15 to 30 feet bls, Zone C is from 30 to 50 feet bls and Zone D is deeper than 50 feet bls. Wells finished in Zone A have TCE concentrations ranging up to 3,090 μg/L. Wells finished in Zone B have TCE concentrations ranging up to 42,400 μg/L. Wells screened in Zone C have TCE concentrations ranging up to 3,160 μg/L. No data were shown for wells deeper than 50 feet.

Figure 1-2 shows the water table occurs approximately 5 feet bls. The top 30 feet of the section is comprised primarily of tan gray and brown fine-grained sand (Unified Soil Classification SP) with several interlayered beds of gray brown silty sand (SM). The top of the Hawthorn Group occurs at approximately 30 feet bls. The Hawthorn Group is described as light green silty to fine to coarse-grained sand with phosphate nodules and shell fragments (SP). These materials appear to become siltier with depth becoming a silty fine-grained sand (SM) at a depth of 42 to 48 feet bls. The Hawthorn clay occurs at approximately 50 feet bls. The Hawthorn clay is described as brown green clayey silt with layers of dark green clay of low plasticity (SC/CL). It is our understanding the Hawthorn clay is considered to be an aquiclude or barrier minimizing vertical migration of the contaminants.

It is our understanding that you would like to consider treating a 50-foot by 50-foot area using EOS® using a recirculation process where groundwater is withdrawn from one or more wells, blended with EOS® concentrate and re-injected. The treatment thickness is proposed to be 50 feet, which presumably would treat all of the aquifer above the Hawthorn clay.

It is our understanding the CH2MHILL would act as the prime contractor for the project and would have the recovery/injection wells installed by others. Solutions-IES would act as a sub-consultant to CH2MHILL and would have the primary responsibility of providing and injecting the EOS® and performing what other services were requested on an "as-needed basis". Such additional services might include providing preliminary design of the well spacing and substrate quantities and various reporting activities or data interpretation after the injection.

Proposed Approach

Solutions-IES has reviewed the information you provided to us. In designing the test area wells, we offer the following suggestions:

- Install injection wells in pairs rather than attempt to screen the entire 50-foot treatment thickness. In other words, install a well pair with the shallow well screened from 5 feet to 25 feet along with a deeper well screened from 30 feet to 50 feet.

- Use the same strategy for the recovery well(s).

Contaminant concentrations appear to range up to 42,400 μg/L in zones A and B but are shown as being much lower within the Hawthorn Group materials deeper than 30 feet bls. The high concentrations suggest the possibility that free-phase TCE (DNAPL) may be present in the shallow zone. Because concentrations decrease below the 30-foot depth, this suggests that the silty sand shown between 25 and 30 feet may function as some sort of barrier restricting downward contaminant migration. Installing injection/recovery wells with long screens through the silty sand may allow downward migration of DNAPL. From the perspective of the pumping well, you would not want to recover water from the shallow zone and inject it into the deep zone for the same reason.

Based on the information provided to us, it appears that four injection well pairs located near the corners of the 50-foot by 50-foot grid would be sufficient. One pair of pumping wells would be located in the center of the test area. Water would be recovered from the center shallow well and used to inject the four corner shallow wells. Then the process would be repeated for the deeper zone wells.

You indicated that CH2MHILL would have the wells installed. Two-inch wells will be used for injection and four-inch wells will be used for recovery. Installing all wells as 4-inch wells would provide greater flexibility in pumping should it be desirable to pump from additional wells. The incremental cost may not be that great.

Solutions-IES would provide the EOS® concentrate and perform the injection. In the costing section below, we have added some upfront engineering or consulting time to assist you with the final design and UIC permit application as well as the Work Plan and Health and Safety Plan if requested. The time would be used to fine-tune the design and to provide you with any data, wording or drawings describing the injection process.

Prior to the start of injection, Solutions-IES personnel will set up a process equipment trailer containing pumps, tanks, and hoses. Solutions-IES will require access to utilities [e.g., water and electricity (single and/or three phase power)] in the vicinity of the process trailer. The EOS® concentrate will be delivered to the site and will need to be stored near the equipment trailer. Prior to injection, Solutions-IES will dilute the EOS® concentrate by mixing 1 part EOS® with 4 to 9 parts water depending on the final design. The diluted EOS will be pumped at low pressure or gravity-drained into each injection well to distribute the EOS® throughout the subsurface. Additional groundwater will be pumped behind the EOS to move it into the formation and increase the hydraulic head toward the center of the test area.

Solutions-IES' personnel will be on site during the injection. If CH2MHILL desires to continue recirculation for an extended period of two to four weeks, CH2MHILL will assume operation and maintenance of the pump and injection system and Solutions-IES will leave the site. Following completion of the EOS® injection, CH2MHILL would ship the pumps back to Solutions-IES. Costs for Solutions-IES to prepare a brief report documenting the injection activities are included in the cost estimate. The report will discuss the injection, summarize the amount of EOS® and chase water injected and any observations made.

Estimated Cost

At the present, many of the final details have to be finalized. As such, the cost of the injection is shown as a range in costs as detailed below. Please note that it is Solutions-IES' practice to process invoice every four weeks. Applicable federal, state and local taxes and permit fees are added to our invoices. All invoices are due upon receipt. Balances outstanding more than 30 days after the invoice date are subject to a monthly finance charge of 1½ percent per month from the invoice date.

Task 1 –Engineering Services (on as-needed basis)	$2,500 to $4,500
Task 2 – EOS® Injection (substrate, labor and equipment)	$55,000 to $70,000
Task 3 – Equipment Rental (continued recirculation)	$500 to $2,000
Task 4 –Reporting/Consulting Services (on as-needed basis)	$3,000 to $5,000
Estimated Range of Costs	$61,000 to $ 81,500

The cost estimate is based on the following:

- 20 drums of EOS concentrate will be provided by Solutions-IES and injected. The final volume is subject to design confirmation.
- The minimum injection costs reflect approximately 1 week of time on site. The high range cost reflects approximately two weeks on site. Obviously recovery and injection rates will control the length of the project.
- The wells will be installed by others. Recovery wells will be 4-inch diameter. Injection wells will be 2-inch diameter. Solutions-IES will provide all pumps hose and mixing equipment to perform the injection.
- Solutions-IES will take reasonable precautions while on-site to minimize property damage to the rights-of-way to the work area and the site. CH2MHILL/US NAVY recognizes that, during completion of services by Solutions-IES under this Agreement, alteration or damage may occur at the site. Client/Property Owner recognizes and accepts that this is inherent in the services provided by Solutions-IES.
- CH2MHILL/US NAVY warrants that any right-of-way provided by property owner to/from the property owner's premises to/from the most convenient way is sufficient to bear the weight of all Solutions-IES and/or our subcontractor's equipment and vehicles required to perform the services.
- Solutions-IES shall not be responsible for damages caused to any private pavement or accompanying subsurface of any route reasonably necessary to perform the services.
- CH2MHILL/US NAVY will provide complete openings, access, and rights-of-way to the work area at all times during the project. The work area will be large enough to accommodate the equipment and materials necessary for the project, and CH2MHILL/US NAVY will provide security.

- Single phase and/or three-phase power drops are available within 100 ft of the work area.
- Water is available from a hydrant or other water supply source within 1,000 ft of the injection area, and secure connections can be maintained between the water source and the work area.
- Subsurface conditions within the injection area are generally as represented in Figure 1-2. The presence of massive foundations and/or buried debris may involve additional costs.
- Weather delays are minimal.
- In preparing our cost proposal, we have assumed that all debris, wastes, washwaters, rinseates, wastewaters, soils, subsoils, and residues generated as a result of the field activities will be disposed of by CH2MHILL/US NAVY. Waste characterization and disposal services are not included in our cost estimate. A separate proposal can be provided for these services, if requested.

Project Team

Solutions-IES is a woman-owned, environmental engineering firm with extensive environmental engineering experience, particularly related to the assessment and remediation of industrial, governmental or other properties where releases of hazardous substances have occurred. We work with and on behalf of our clients to find cost-effective, practical solutions to their environmental problems. All key technical personnel have the necessary experience and expertise, as highlighted in the brief biographical sketches provided below.

Christie Zawtocki P.E. – Project Manager: Christie has a M.S. in Environmental Engineering, and most of her work has focused on soil and groundwater assessment and remediation projects. She has worked at a variety of government, industrial, and commercial sites located in NC, SC, TX, CA, MD, and OK. Her work has included soil and groundwater sampling, aquifer testing, natural attenuation screening assessments, soil stabilization studies, remedial alternative evaluations, risk-based cleanup level evaluations, and remedial system design, implementation and performance evaluation. Christie is the lead engineer and/or project manager on many of Solutions-IES' emulsified oil projects. This includes development of monitoring and demonstration plans, design of the injection system, groundwater flow and transport modeling, and reporting. Christie's expertise with design, implementation, monitoring, and reporting will be utilized in managing all project activities at your site. Christie will be responsible for maintaining communication with CH2MHILL and assuring that requirements for scope, schedule and cost are met.

Walter J. Beckwith, P.G. – Director of Technical Services: Walt Beckwith has a B.S. degree in Geology and is a licensed geologist in six states. He has over 30 years of field sampling, testing, and assessment experience and is well recognized in the environmental consulting industry. In 2000/2001, Walt served as the President of the Groundwater Professionals of North Carolina. His unique ability to implement and oversee field services, solve field problems, and interpret site conditions, provides an invaluable benefit to his clients. Walt has personally performed and overseen assessment and remediation of fuel related and chlorinated solvent sites using excavation, soil vapor extraction, air sparging, enhanced bioremediation, monitored natural attenuation, and pump-and-treat technologies. His expertise was used extensively in evaluating the contaminant fate and transport at statewide NCDOT asphalt-testing sites that were contaminated with TCE. Walt has served as field team leader on numerous Solutions-IES' remediation sites including participating in and overseeing the design and implementation of EOS® barriers of at three Air Force Bases and three industrial sites to date. Walt's extensive field experience will be used to assist with the design and implementation of the EOS® injection activities at your site.

Brian Rebar – Field Services Manager: Brian is a licensed Well Drilling Contractor in North Carolina. He has installed air sparging, soil vapor extraction, bio-sparging, pump-and-treat, free product recovery, bioslurping, and infiltration gallery systems for the remediation of soil and/or groundwater. Brian is

Solutions-IES' technical lead for remediation system operation and maintenance (O&M). Brian has also taken the lead in conducting the injection and monitoring activities for multiple Solutions-IES EOS® sites. Brian's experience will be used to head site-specific field team efforts.

Authorization

If you elect to accept our proposal by issuing a purchase order, then please reference this proposal number (Solutions-IES Proposal No. NC05335P) and date. Your purchase order will be an acceptance of our Agreement for Services and an authorization to proceed with the performance of our services. Unless otherwise agreed in writing signed by Solutions-IES, any and all services provided to CH2MHILL pursuant to the acceptance of a proposal by Solutions-IES, a written contract, a purchase order, or other evidence of an agreement between Solutions-IES and CH2MHILL where a copy of our Agreement for Services has been provided in advance to CH2MHILL, shall be deemed to be controlled by our Agreement for Services and incorporated into any other among the parties, whether or not contrary terms are included in a purchase order or other document provided by CH2MHILL.

Closing

Solutions-IES appreciates the opportunity to provide this proposal to you. We look forward to your favorable reply and an authorization to proceed. If you have any questions regarding information contained in this proposal, please feel free to contact us at 919-873-1060.

Yours truly,
Solutions-IES

Walter J. Beckwith, P.G.
Director of Technical Services

M. Tony Lieberman
Bioremediation Program Director

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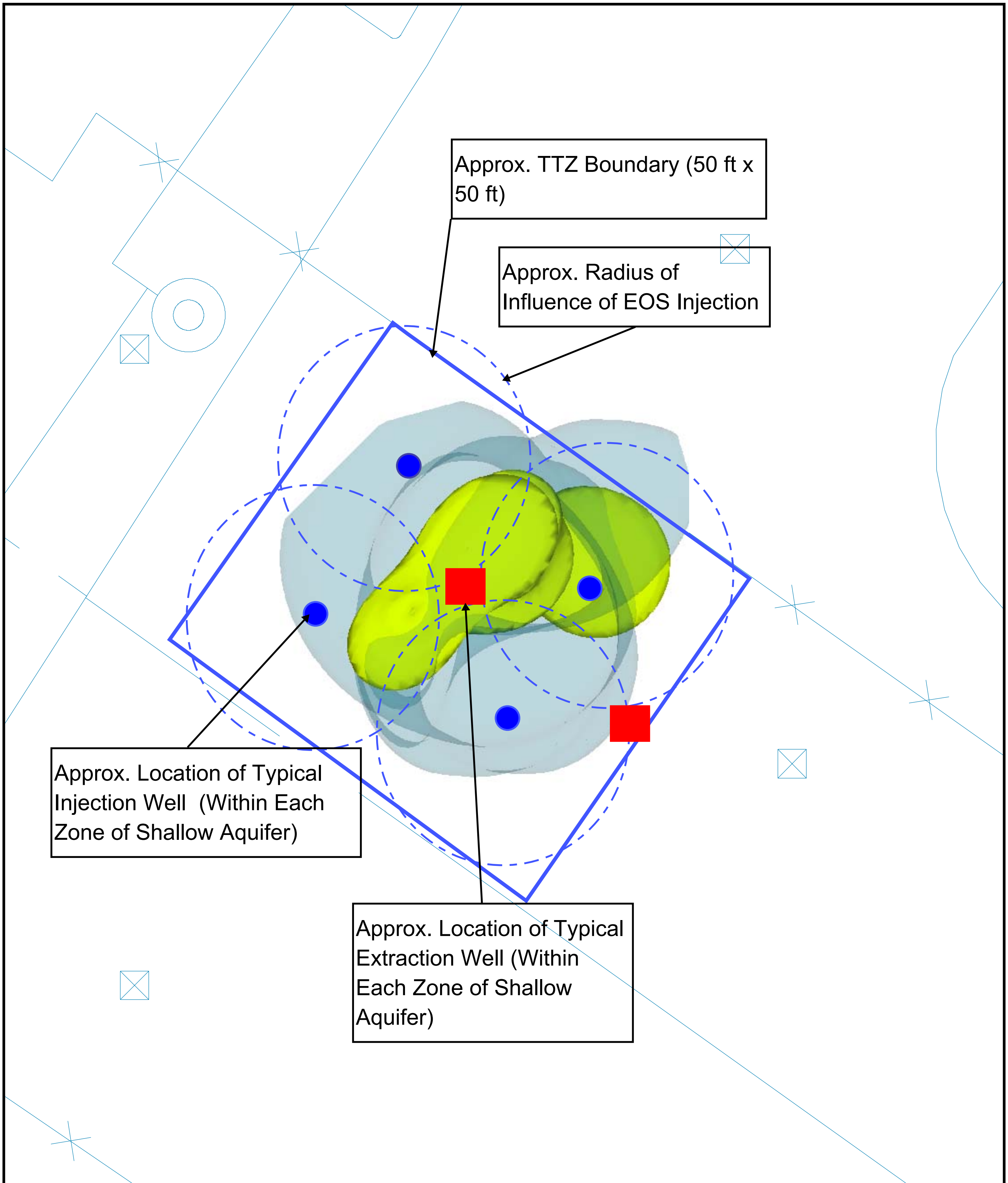
Attachment B-4: Sketches of Well Configurations for Alternatives 2A and 2B

NOTE: Original figure created in color



Blue - 10,000 ppb TCE in Groundwater
Green - 10,000 ppb TCE in Soil

N

0 10 20 Feet

1 inch = 18.6544 feet

Figure B-4

Proposed Injection and Extraction Well Scheme EOS Injection Approach
SA 17, NTC Orlando

CH2MHILL

File Path: c:\ntc gis\ntc-sa17.apr, Date: 27 Feb 2004 9:17, User: PFAVARA, Figure 4-1 10,000 ppb in Soil and Groundwater

Appendix H

Copy of Aquifer pump Test Report and Groundwater Flow Simulation Modeling Report

Orlando Naval Training Center Study Area 17 (SA-17) Aquifer Performance Test

PREPARED FOR: CH2M HILL/ATL

PREPARED BY: CH2M HILL/TPA

COPIES:

DATE: September 26, 2005

This technical memorandum summarizes the aquifer performance testing (APT) conducted at the Orlando, Florida Navy Training Center Study Area 17 (SA-17). Aquifer testing was conducted by CH2M HILL to confirm aquifer characteristics and provide local hydrogeologic parameters that will assist in the design of a ground water remediation system for the treatment of dissolved chlorinated volatile organic compounds (CVOCs).

Tables and Figures are located at the end of the report in the order they are referenced. Attachments follow the Tables and Figures.

Background

The Navy Training Center SA-17 is located west of the Orlando International Airport. The location of the site is shown in **Figure 1**. The CVOC contamination at SA-17 is within the surficial aquifer. The current plan to remediate the site will be remediated by injecting emulsified oil substrate around the outer perimeter of contamination plume while pumping from a recovery well located in the center of the plume to maintain a gradient towards the center of the contamination area. The purpose of this report is to establish localized hydraulic parameters of the surficial aquifer that will confirm the design of the remediation system.

Hydrogeology

The surficial aquifer at SA-17 exists to approximately 50 feet bls and consists primarily of sand with intermittent layers of low porosity silty sand. The subsurface has been delineated into different zones based on semi-confinement layers that exists within the aquifer. The zones are designated A, B, C, and D. Zone A extends from 5 to 15 feet below land surface (bls), Zone B from 15 to 30 feet bls, Zone C from 30 to 50 feet bls, and Zone D deeper than 50 feet bls. The surficial aquifer consists of Zones A, B, and C. In some locations across the study area a thin layer of lower permeability silty sand separates Zone A and Zone B. A thin layer of semi-confining silty sand separates Zone C from Zones A and B. Zone D is the upper Hawthorn Aquifer and is separated from the surficial aquifer by a confining clay layer. **Figure 2** provides a generalized hydrogeology of the site.

APT Setup

The pumped well (OLD 17- MW 51C) is a 2-inch diameter well screened from 42 feet to 47 feet bls (Zone C). Eight new 1-inch diameter PVC peiziometers were constructed prior to the pump test to be used as monitoring wells (PZ-01S, PZ02S, PZ-03S, PZ-04S, PZ-01D, PZ-02D, PZ-03D, and PZ-04D). The piezometers designated with an "S" (shallow) are complete with a screened interval from 20 feet to 21 feet bls (Zone B). The "D" (deep) piezometers are completed with screened intervals from 35 feet to 36 feet bls (Zone C). Other wells previously constructed were also monitored and have screened intervals in Zones A, B or C. **Table 1** lists the wells monitored during the pumping test and their respective screened interval zone. **Figure 3** is a location map of the monitoring wells.

APT Test Execution

The constant rate pumping test was initiated at OLD Well 17 –MW 51C (51C) on August 16, 2005. Prior to the constant rate test, background water level data were recorded at several of the monitoring wells for a period of seven days. **Figure 4** is a summary of the background water level data. A short-term preliminary pumping test (2 hours) was conducted the day before the final constant rate test to establish a sustainable flow rate for the test. The final constant rate pumping test was approximately 8 hours in duration. Flow rates were calculated by recording the time to fill a container of known volume. A flow rate of 5 gpm was sustained for the 8-hour testing period. Water levels were recorded using electronic data loggers (In-Situ Hermit 3000, Minitrolls, or Troll 4000s). Manual water level measurements were recorded as a back-up to the electronic data or as a substitute for wells that did not have transducers installed.

Water levels recorded the morning of the 8-hour test were used as static reference water levels in the calculation of pumping drawdowns. Close examination of the data reveals that these water levels were lower than the reference water levels established prior to starting the preliminary test on August 15, 2005 (when PZ data loggers were initiated). The lower water levels on the morning of the test (August 16, 2005) initially suggest that the wells had not fully recovered from the preliminary test and that the August 15 water level should have been used as the static reference for the constant rate test. After further study it was determined that a substantial rain fall event had occurred prior to the preliminary test which elevated the water table to an artificial level at the time the preliminary test reference water levels were recorded. In the time between the preliminary test and the constant rate test, the water levels began falling to equilibrium, or pre-rain levels. This is supported by evidence in the background water levels recorded in the monitoring wells prior to the rain event that indicated lower water levels. Also, the water levels recorded during the recovery phase did not approach pre-pump test levels. Finally, a decreasing water level trend was noted in the background data recorded after the pumping test recovery phase indicating that the aquifer was still recovering from the rain event. Therefore, the August 16 pre-test water level was thought to be more representative of true background conditions and were used as the static reference for the drawdown calculations. A plot of the rain fall data recorded from the McCoy rain gauge by the South Florida Water Management District is provided in **Figure 5**.

Due to the continuous decrease in water levels over time during the testing, each pumping test data set was adjusted to offset this naturally decrease in water levels. The adjustment was made by calculating the slope of the decreasing water level trend noted in the background data after the testing period for each well to establish a water level delta over time. This value was then subtracted from each data set. For wells that did not have background data following the pumping test period, an average from the wells constructed within the same zone for which a slope was established was used to adjust the data set.

APT Hydraulic Evaluation Results

At a pumping rate of 5 gpm, drawdown measured in the pumped well was approximately 30 feet, giving a specific capacity of 0.167 gpm/ft. Drawdown response was significantly localized around the pumped well. Zone C monitoring wells located only 11 feet away from the pumped well showed drawdowns of approximately 1.2 feet. In Zone B, drawdowns were 0.5 feet or less in wells ranging from 11 to 25 feet away. The data suggests that a slightly more pronounced hydraulic connection exists between Zone B and Zone C to the northeast of the pumped well as compared to the area southeast of the pumped well. This is based on more drawdown noted in the Zone B wells and less drawdown in the Zone C wells in the northeastern wells compared to the southeastern wells, suggesting better hydraulic connection in the northeastern area and slightly more confinement (or less hydraulic connection) in the southeastern area between Zones B and Zones C. Two wells monitored in Zone A (S09 and 23A) had similar drawdown responses. Well S09 to the northeast of the pumped well showed drawdown of 0.14 feet and 23A located to the southwest exhibited 0.18 feet of drawdown. Plots of the drawdown data for the pumped well, Zone A wells, Zone B wells, and Zone C wells are provided in **Figures 6-9** respectively.

To calculate transmissivity and storativity of the aquifer, the water level drawdown data were analyzed using AquiferWin32® pump test analysis software. Two analysis methods were used; Hantush and Jacob (1955), and Neuman (1972). Standard analysis methods such as Cooper and Jacob (1946), Theis Recovery, and Theim Distance Drawdown were not used due to the assumption of confined aquifer conditions for each of these methods. Analysis using these methods produced uncharacteristically high transmissivity values. The aquifer response during the pumping test appeared to resemble delayed gravity leakance characteristics, which is typical of unconfined sandy aquifers such as the surficial aquifer. Therefore the Hantush (1955) for leaky aquifers and Neuman (1972) for unconfined aquifers were more appropriate analysis methods. Assumptions for these two methods are provided below.

Neuman, 1972

- The aquifer is unconfined.
- The aquifer has a seemingly infinite areal extent.

- The aquifer is homogeneous and of uniform thickness over the area influenced by the test.
- Prior to pumping, the watertable is horizontal over the area that will be influenced by the test.
- The aquifer is pumped at a constant discharge rate.
- The well penetrates the entire aquifer and thus receives water from the entire saturated thickness of the aquifer.
- The aquifer is isotropic or anisotropic.
- The flow to the well is in an unsteady state.
- The influence of the unsaturated zone upon the drawdown in the aquifer is negligible.
- An observation well screened over its entire length penetrates the full thickness of the aquifer.
- The diameters of the pumped and observation wells are small, i.e. storage in them can be neglected.

Hantush and Jacob, Leaky Aquifer 1955

- The aquifer is leaky
- The aquifer and the aquitard have an infinite areal extent
- The aquifer and aquitard are homogeneous, isotropic and of uniform thickness over the area influenced by the test
- Prior to pumping the piezometric surface and the water table are horizontal over the area that will be influenced by the test
- The aquifer is pumped at a constant discharge rate
- Well penetrates the entire thickness of the aquifer and thus receives water by horizontal flow
- The flow in the aquitard is vertical
- The drawdown in the unpumped aquifer (or in the aquitard, if there is no unpumped aquifer) is negligible
- The water removed from storage in the aquifer and the water supplied by leakage from the aquitard is discharged instantaneously with decline of head
- The diameter of the well is small, i.e. the storage in the well can be neglected
- The flow to the well is in an unsteady state
- The aquitard is incompressible, i.e. the changes in aquitard storage are negligible

The calculated transmissivities for the surficial aquifer were characteristically low for a sand aquifer. Transmissivities for Zone B and Zone C were similar, with average values of 140 ft^2/day (1,047 gpd/ft) and 138 ft^2/day, respectively. Assuming an aquifer thickness of 30 feet for Zone B the hydraulic conductivity is estimated to be 4.7 ft/day. The hydraulic conductivity of Zone C, assuming an aquifer thickness of 20 feet, is approximately 6.9

ft/day. The average storativity of Zone B and Zone C were calculated to be 0.05 and 0.02, respectively. Data collected from the Zone A wells were either insufficient or too erratic to analyze which precluded calculations of the transmissivity and storativity for this Zone. **Table 2** summarizes the aquifer testing results. Analysis plots are provided as **Attachment A**.

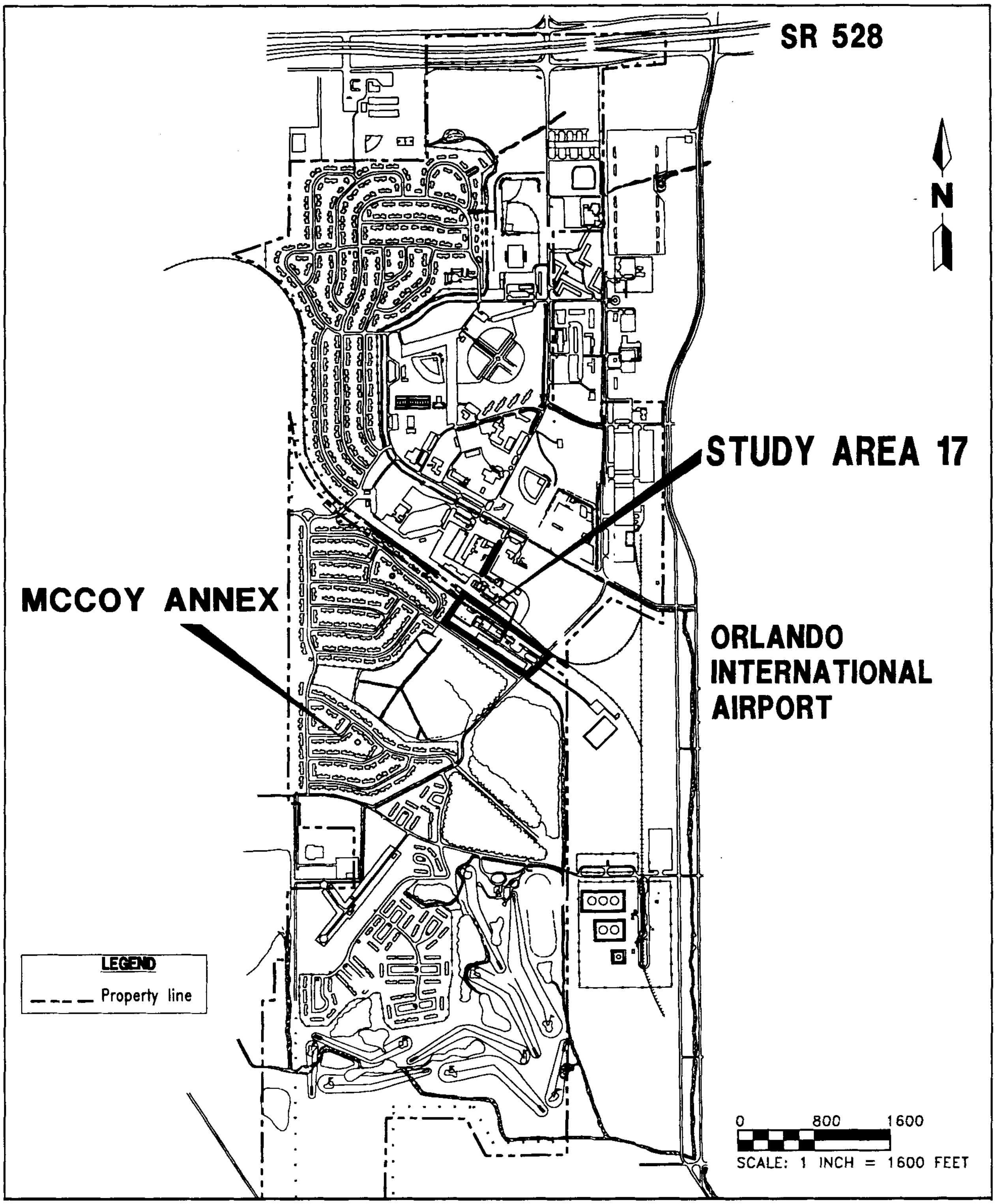
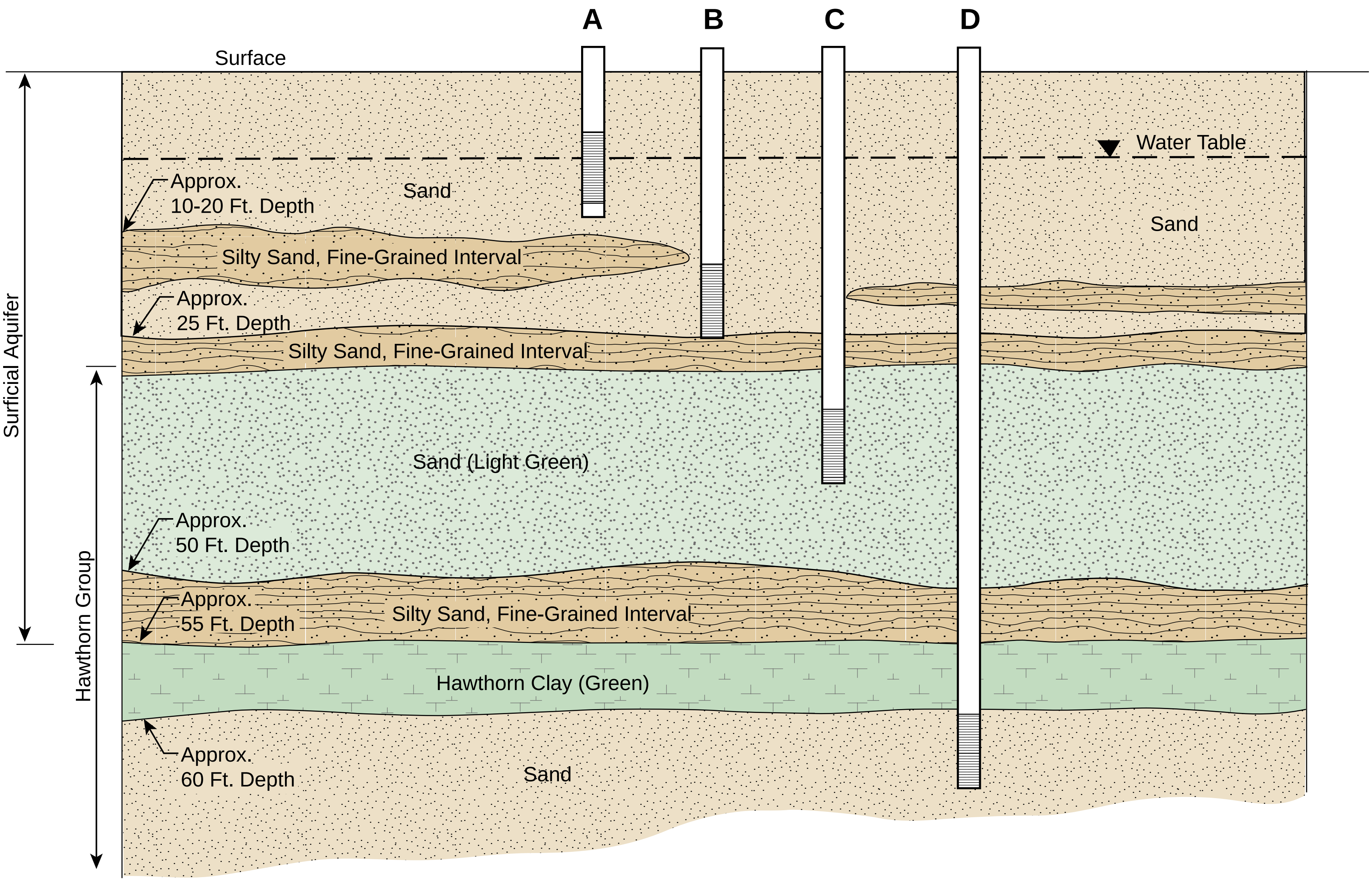


FIGURE 1
Site Plan
Aquifer Performance Test
Naval Training Center, Orlando, Florida
Study Area 17



NOTE: Wells have varying screen lengths from 1' to 5'

FIGURE 2
Generalized Site Hydrogeology
Aquifer Performance Test
Naval Training Center, Orlando, Florida
Study Area 17

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Table 1

List of Monitoring Wells

Aquifer Performance Test - Naval Training Center Orlando Florida Study Area SA-17

Well	Distance to Pumped Well	Zone of Screen Interval	Data Collection Method Used for Analysis	Top of Casing Elevation (feet)
23A	8.76	A	Manual	89.38
S-09	19.38	A	Manual	86.15
24B	10.85	B	Electronic	89.56
I-27	11.46	B	Manual	86.86
D-32	15.36	B	Electronic	85.80
D-34	15.12	B	Manual	85.85
I-30	24.67	B	Manual	87.59
PZ-01S	21.59	B	Electronic	90.315
PZ-02S*	11.18	B	N/A	90.18
PZ-03S	11.23	B	Electronic	90.91
PZ-04S*	21.38	B	N/A	89.81
PZ-01D	21.17	C	Electronic	90.13
PZ-02D	10.30	C	Electronic	90.125
PZ-03D	10.96	C	Electronic	89.96
PZ-04D	20.82	C	Electronic	89.96
51C	0.00	C	Electronic	89.66

* Data Logger Malfuction - Data not used for analysis

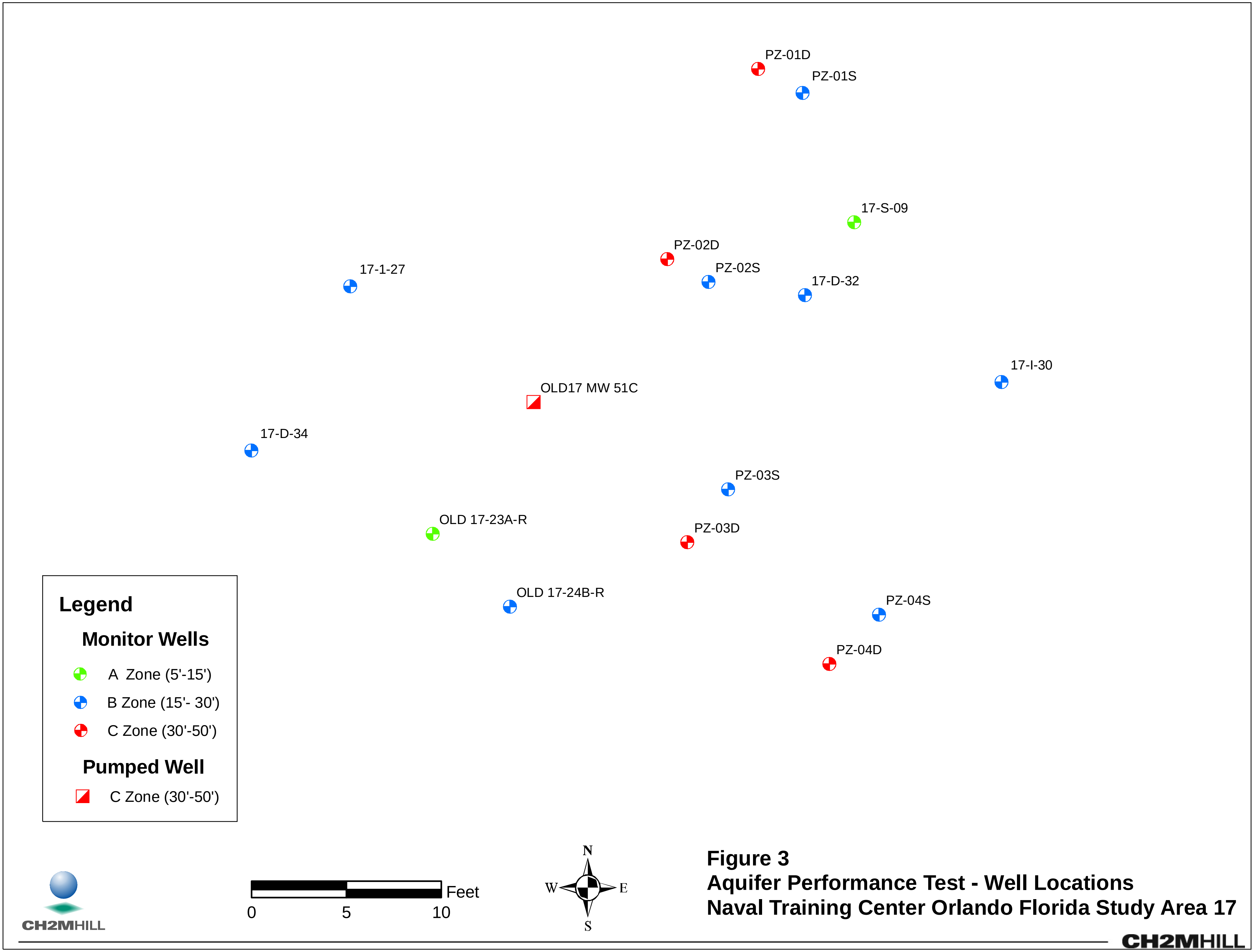

Figure 3
Aquifer Performance Test - Well Locations
Naval Training Center Orlando Florida Study Area 17

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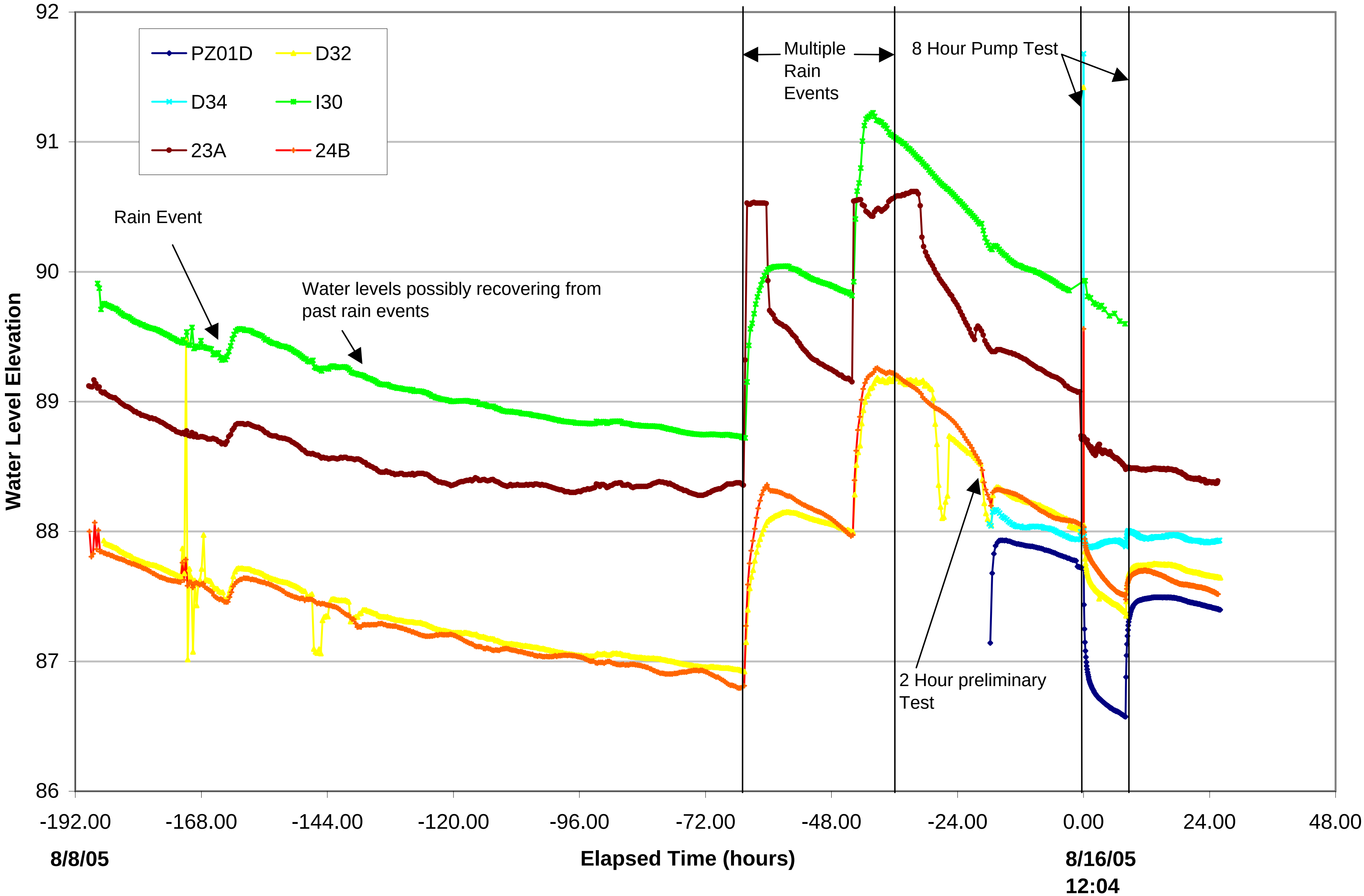

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Figure 4

Background, Pumping Test, and Recovery Water Elevation

Aquifer Performance Test - Naval Training Center Orlando Florida Study Area SA-17

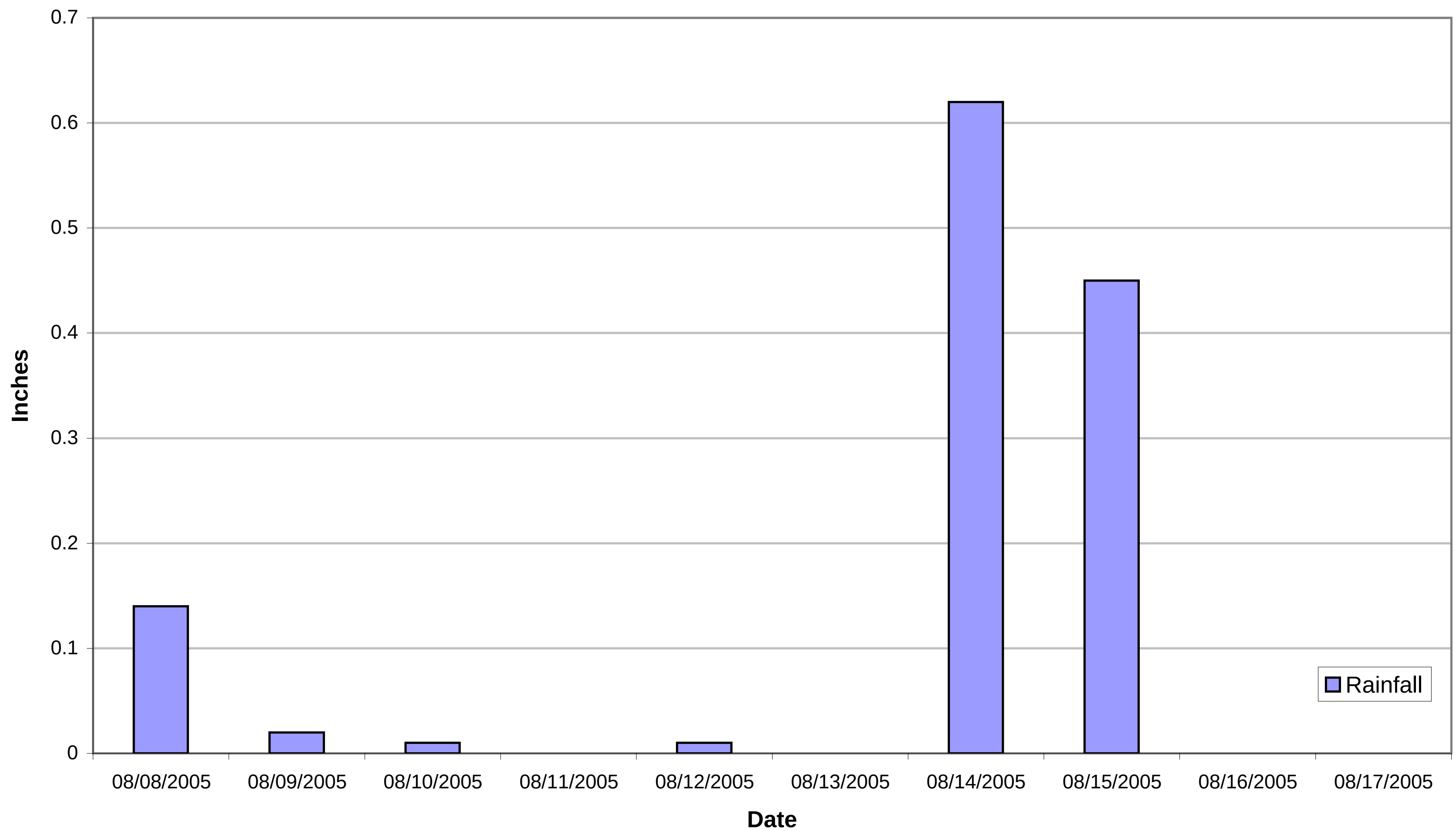

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Figure 5

Rainfall Data - SFWMD McCoy Station

Aquifer Performance Test - Naval Training Center Orlando Florida Study Area SA-17

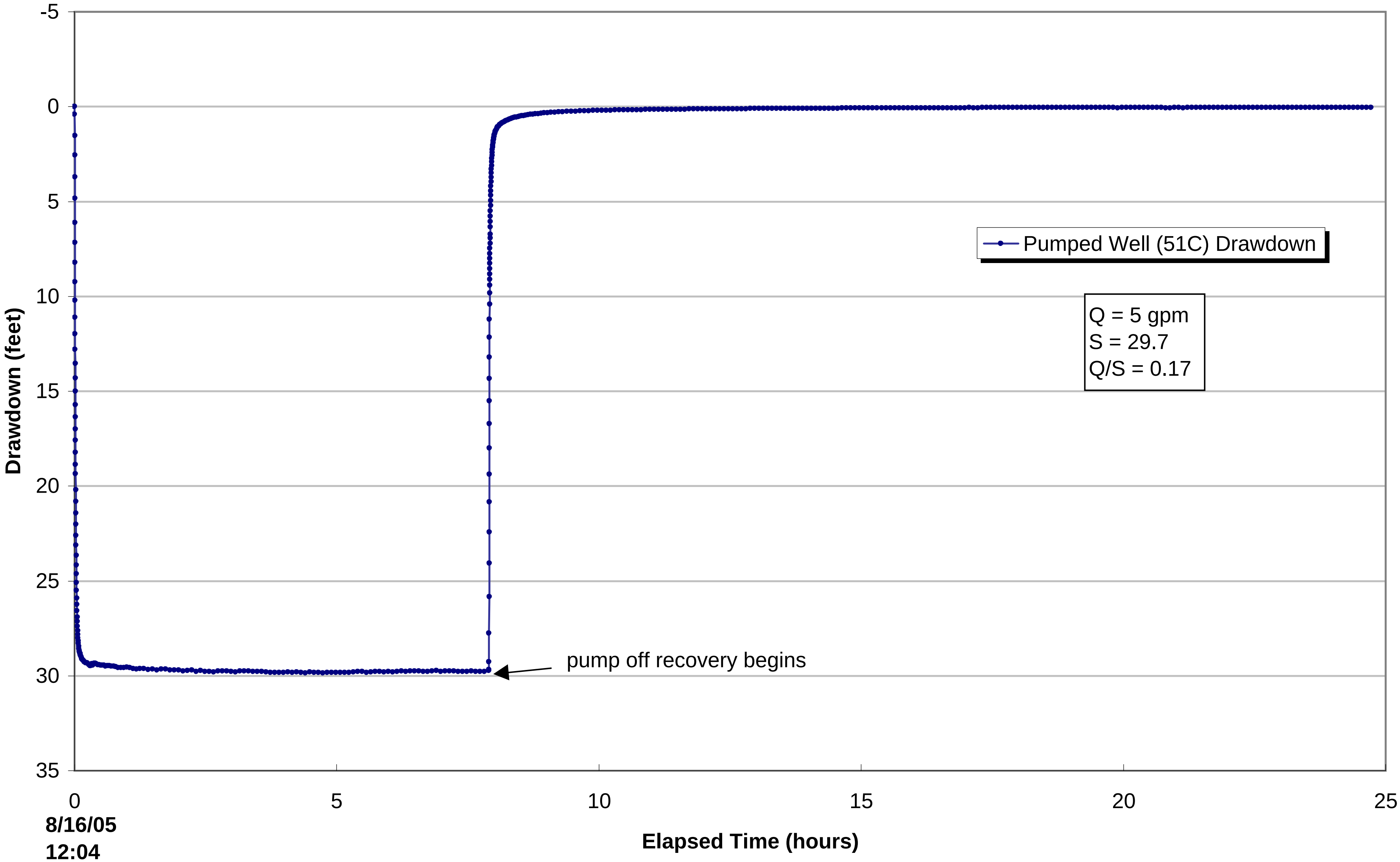

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Figure 6

Constant Rate Pumping Test - Pumped Well Drawdown Response

Aquifer Performance Test - Naval Training Center Orlando Florida Study Area

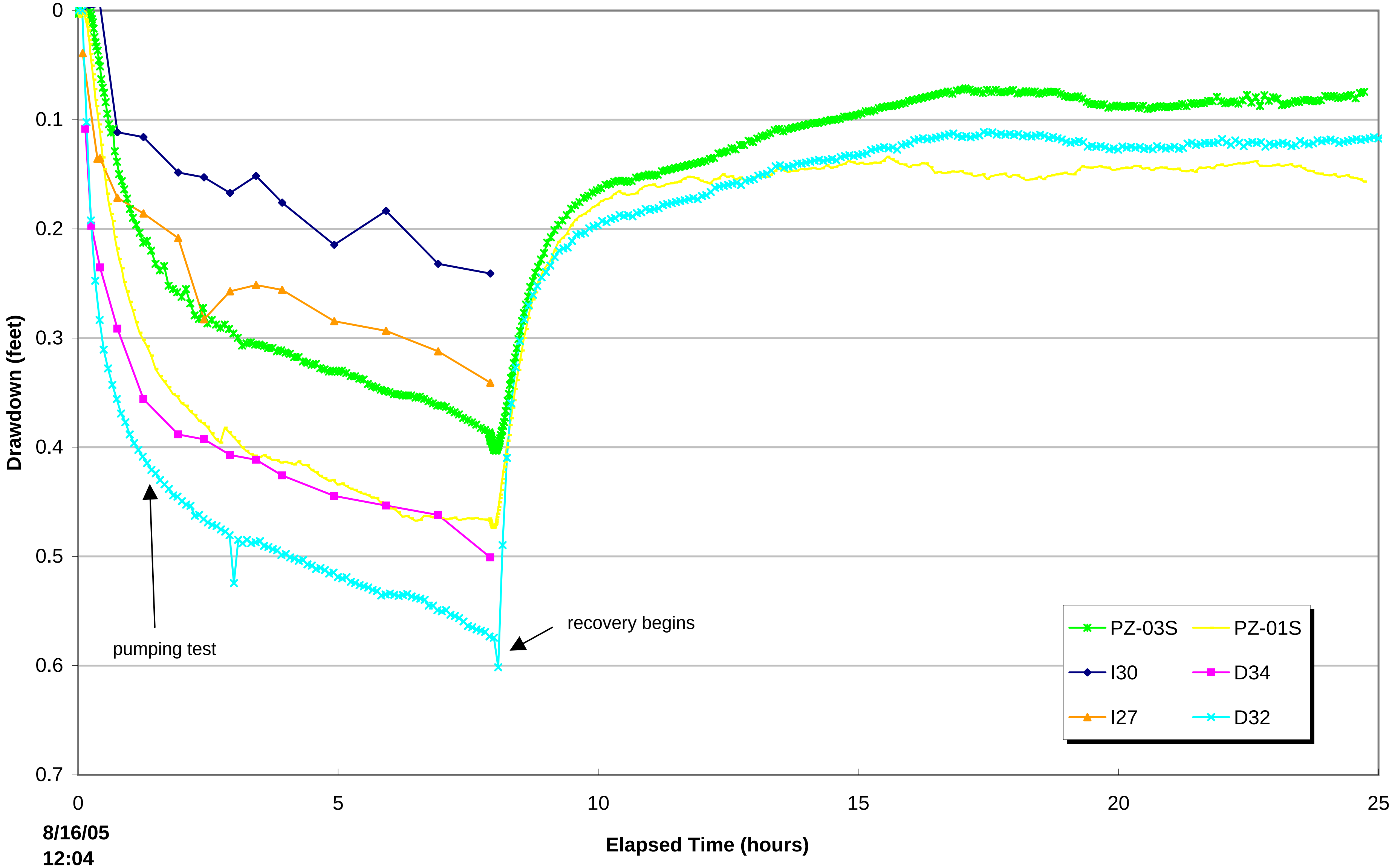
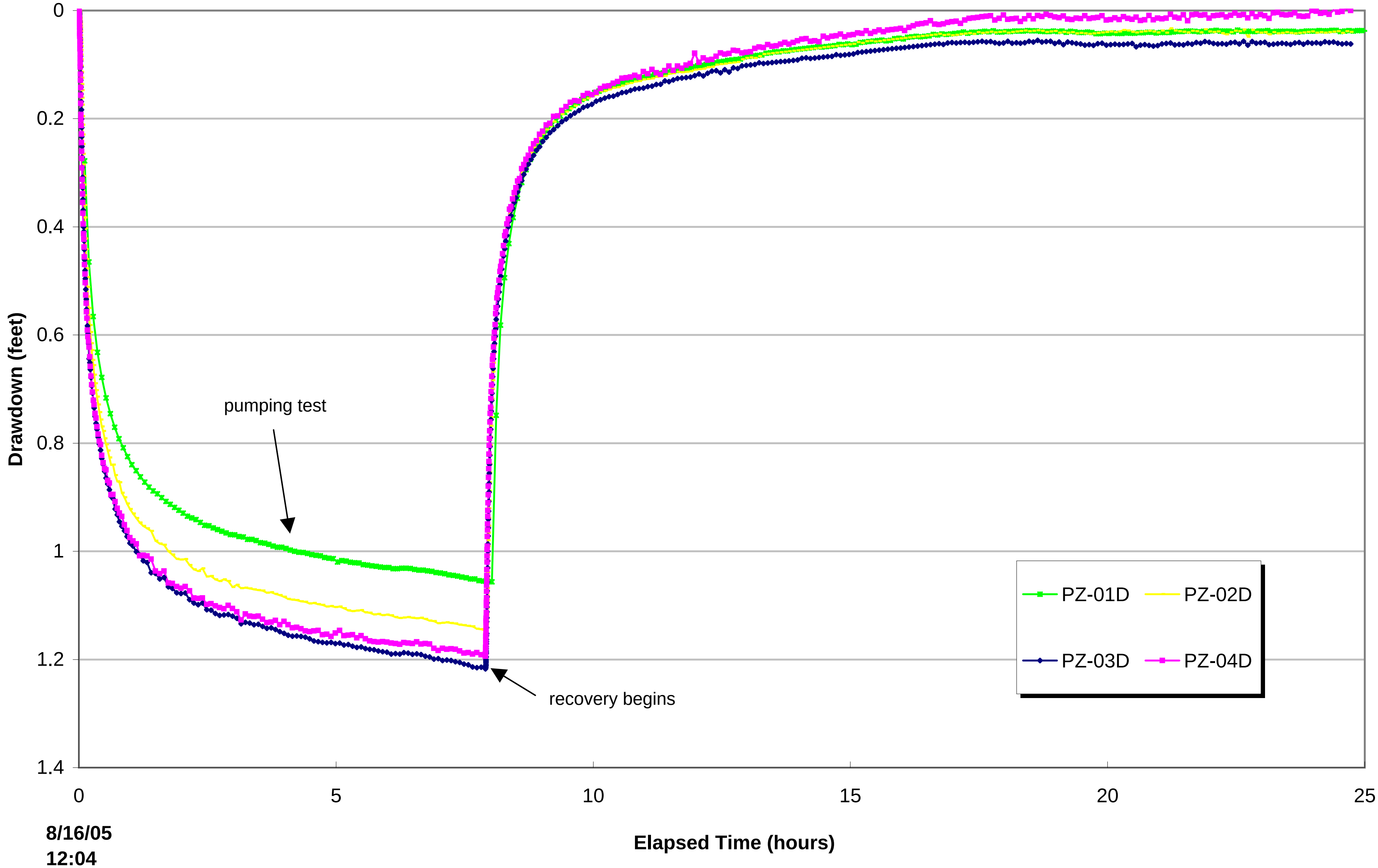


Figure 7

Constant Rate Pumping Test - Zone B Drawdown Response

Aquifer Performance Test - Naval Training Center Orlando Florida Study Area SA-17

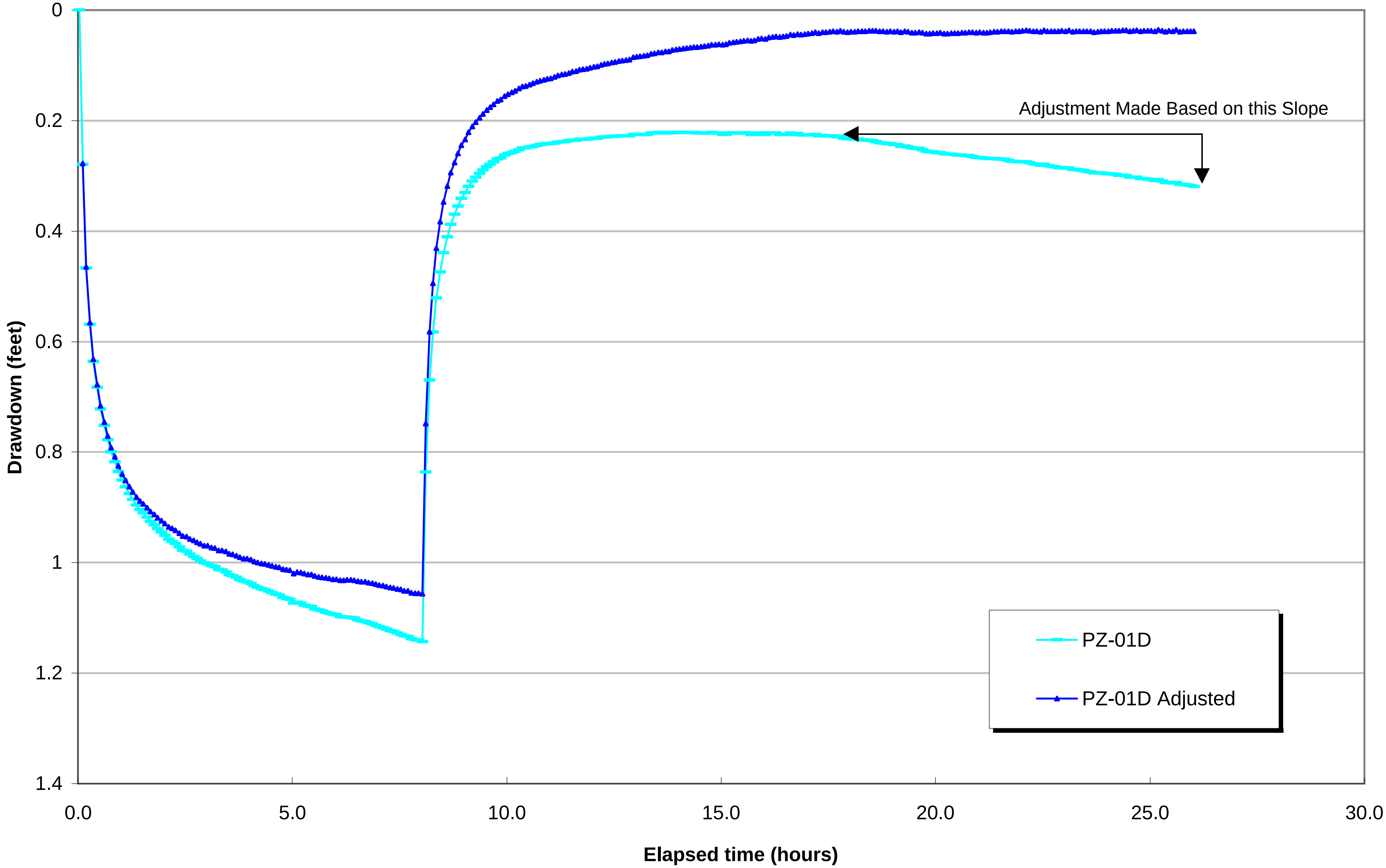


CH2MHILL

Figure 8

Constant Rate Pumping Test - Zone C Drawdown Response

Aquifer Performance Test - Naval Training Center Orlando Florida Study Area SA-17



CH2MHILL

Figure 9

Example of Data Adjustment To Offset Rainfall Recharge

Aquifer Performance Test - Naval Training Center Orlando Florida Study Area SA-17

Table 2

Summary of Aquifer Test Results

Aquifer Performance Test - Naval Training Center Orlando Florida Study Area SA-17

Zone	Observation Well	Distance from pumped well (feet)	Drawdown (feet)	Specific Capacity (gpm/ft)	Transmissivity (gpd/ft)	Transmissivity (ft2/d)	Hydraulic Conductivity (ft/d)	Storativity	Analysis Method
A	23A	8.76	0.18	-	-	-	-	-	-
	S-09	19.38	0.14	-	-	-	-	-	-
B	24B	10.85	0.38	-	1,249	167	5.6	9.10E-02	Hantush
				-	1,234	165	5.5	3.50E-02	Neuman
	I27	11.46	0.34	-	-	-	-	-	-
	32D	15.36	0.57	-	1,466	196	6.5	1.90E-02	Hantush
				-	1,466	196	6.5	1.90E-02	Neuman
	34D	15.12	0.50	-	-	-	-	-	-
	I30	24.67	0.24	-	-	-	-	-	-
	PZ-01S	21.59	0.47	-	785	105	3.5	1.70E-02	Hantush
				-	778	104	3.5	1.60E-02	Neuman
	PZ-02S	Equipment Malfunction		-	-	-	-	-	-
	PZ-03S	11.23	0.39	-	688	92	3.1	9.30E-02	Hantush
				-	711	95	3.2	9.10E-02	Neuman
	PZ-04S	Equipment Malfunction		-	-	-	-	-	-
				Average	**1,047**	**140**	**4.7**	**4.76E-02**	
C	51C	pumped well	29.8	0.167	-	-	-	-	-
	PZ-01D	21.17	1.06	-	1,092	146	7.3	3.40E-03	Hantush
				-	950	127	6.4	5.70E-03	Neuman
	PZ-02D	10.3	1.15	-	980	131	6.6	9.10E-02	Hantush
				-	1,032	138	6.9	8.90E-03	Neuman
	PZ-03D	10.96	1.22	-	950	127	6.4	7.10E-03	Hantush
				-	965	129	6.5	6.80E-03	Neuman
	PZ-04D	20.82	1.19	-	1,062	142	7.1	1.75E-03	Hantush
				-	1,234	165	8.3	1.72E-03	Neuman
				Average	**1,033**	**138**	**6.9**	**1.58E-02**	

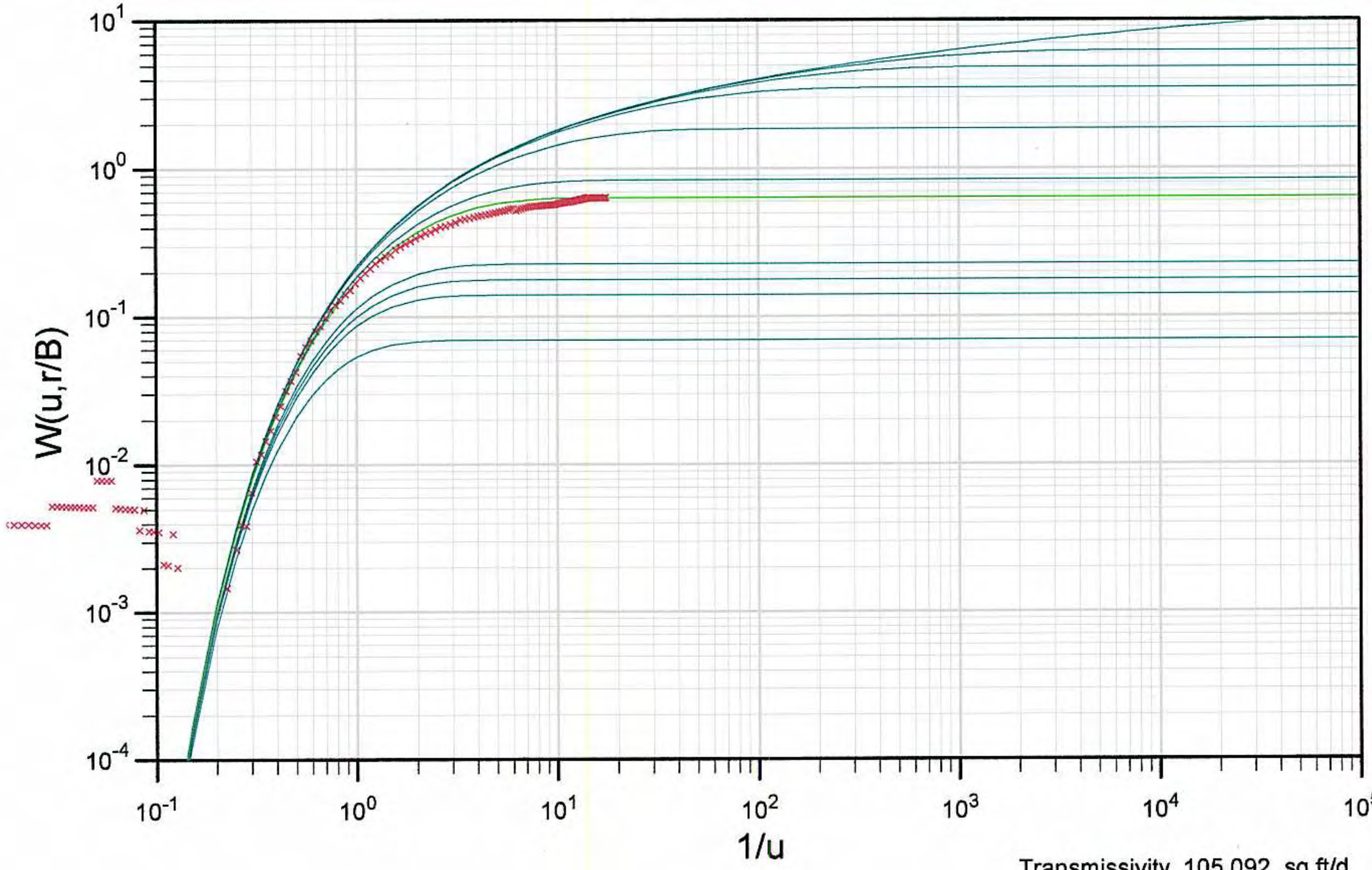
Notes:

Pumped Well = 51C (Zone C)
Pump rate = 5 gpm
Pumping Duration = 8 hours

For Hydraulic Conductivity - Zone B assumed to be 30 feet thick, Zone C assumed to be 20 feet thick
Neuman, 1972 (Unconfined Aquifer)
Hantush and Jacob, 1955 (Leaky Aquifer)

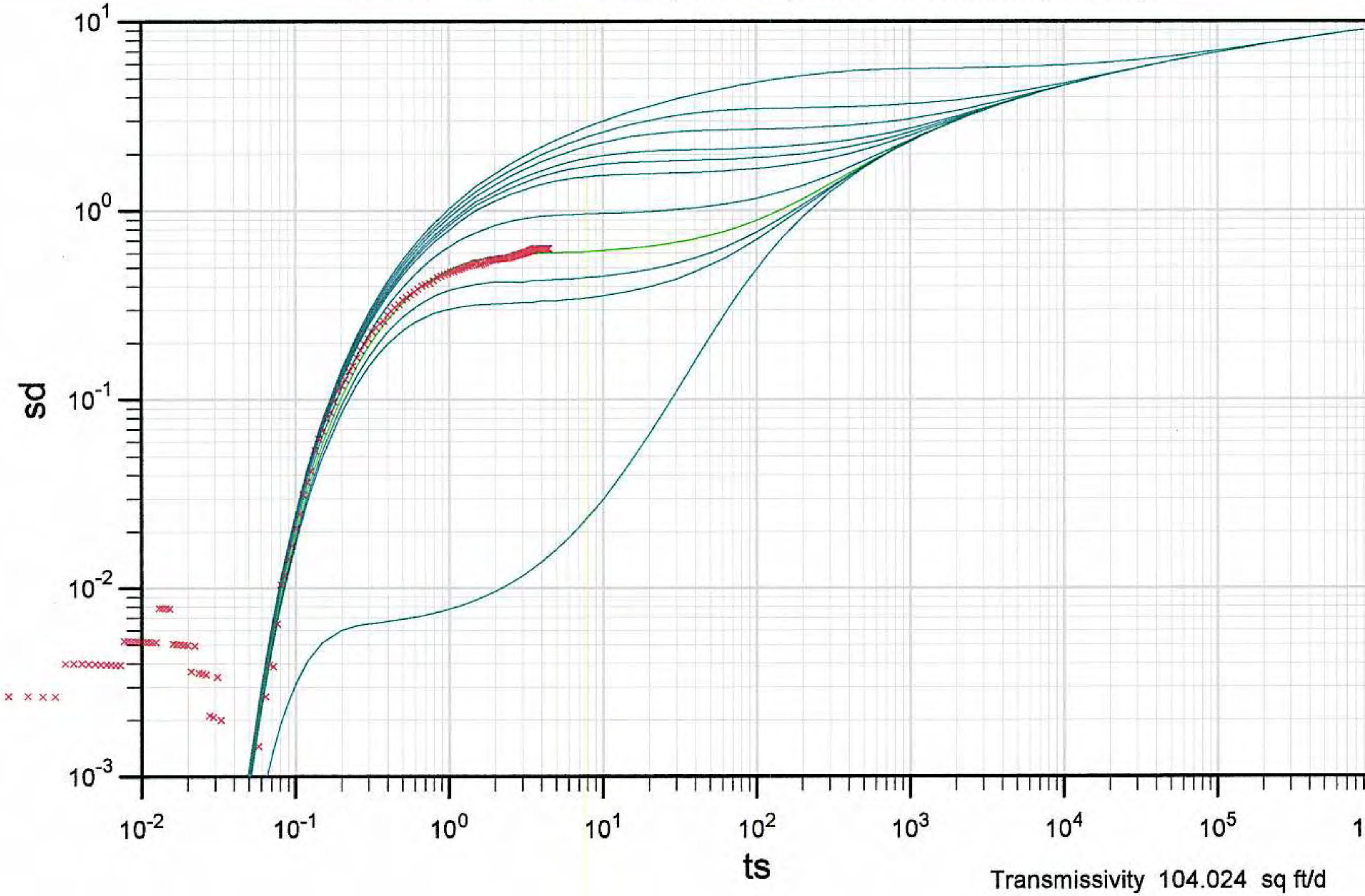
gpm = gallons per minute
ft2/d = square feet per day
gpd/ft = gallons per day per foot

PZ-01S - Hantush, 1955 (Leaky Aquifer)



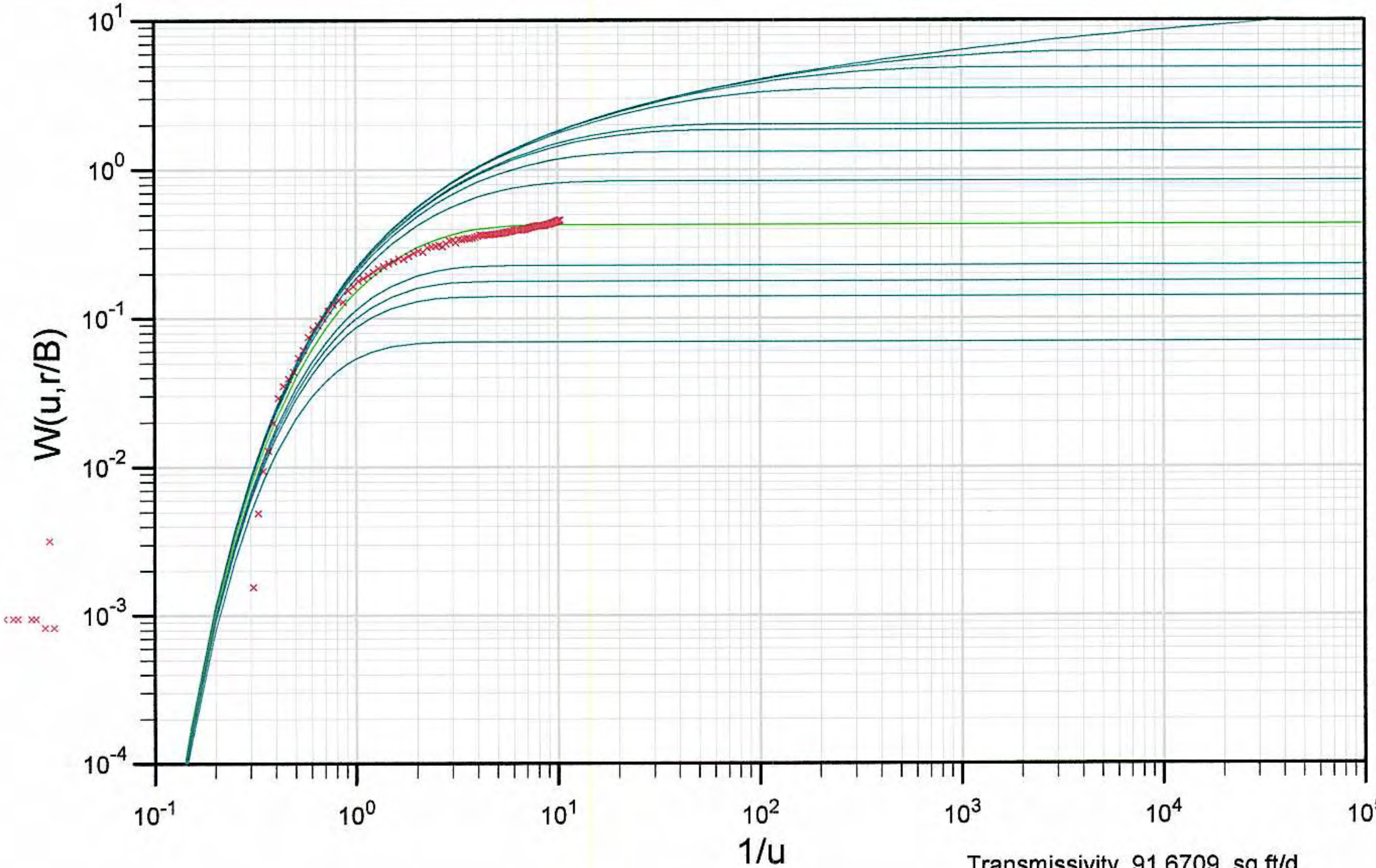
Transmissivity 105.092 sq ft/d

PZ-01S - Neuman, 1972 (Unconfined Aquifer)



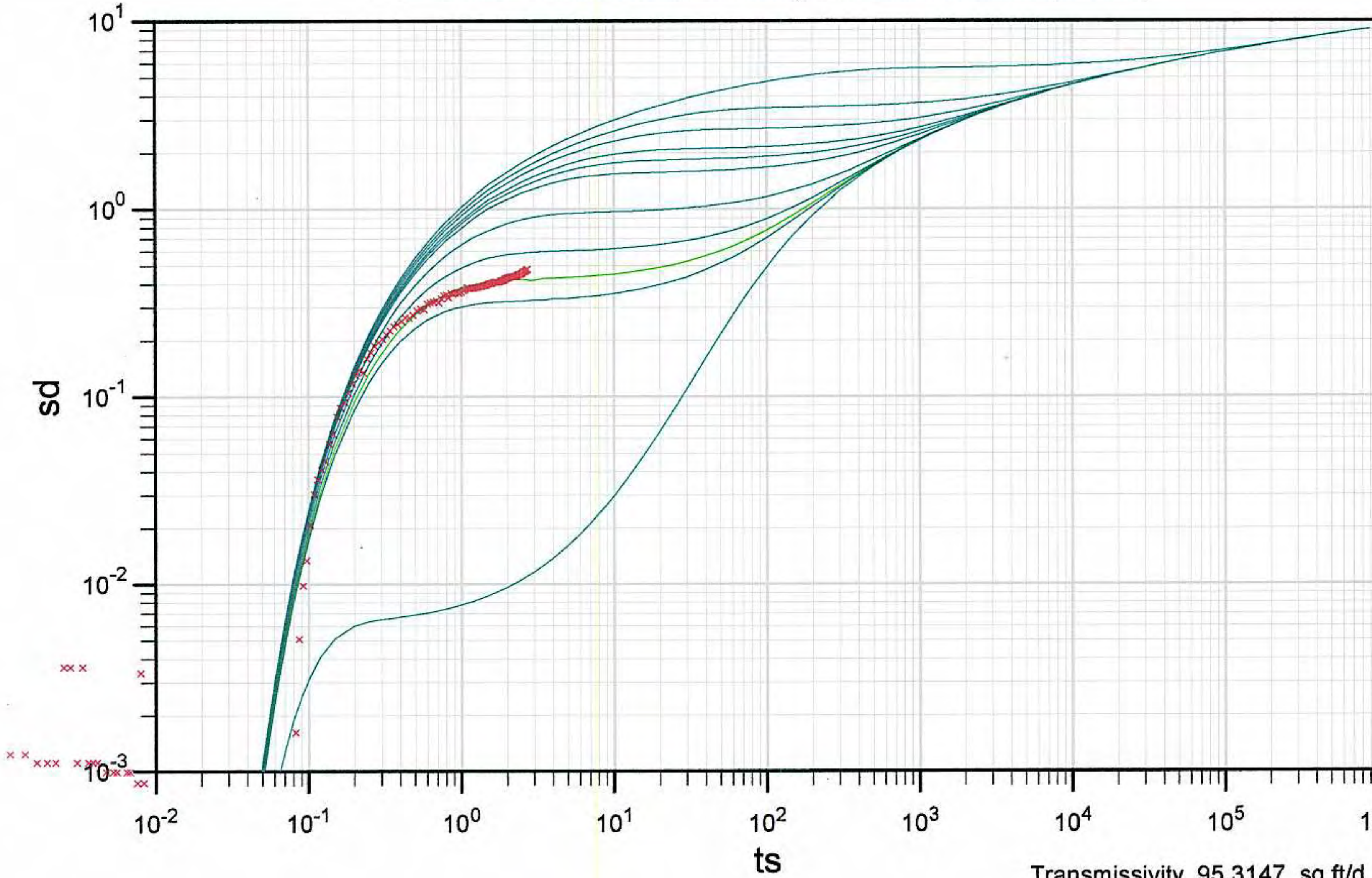
Transmissivity 104.024 sq ft/d

PZ-03S Hantush,1955 (Leaky Aquifer)



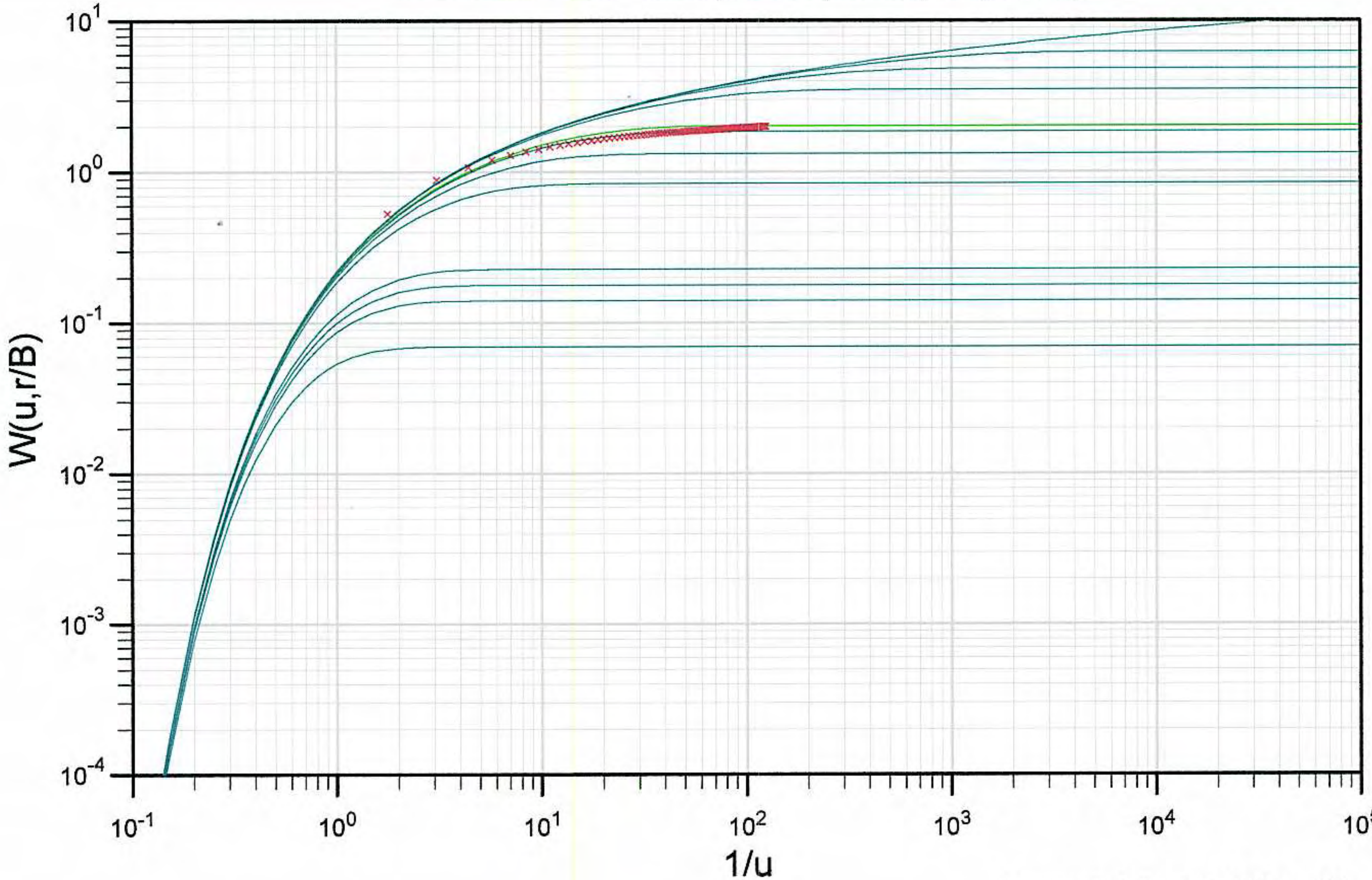
Transmissivity 91.6709 sq ft/d

PZ-03S - Neuman, 1972 (Unconfined Aquifer)



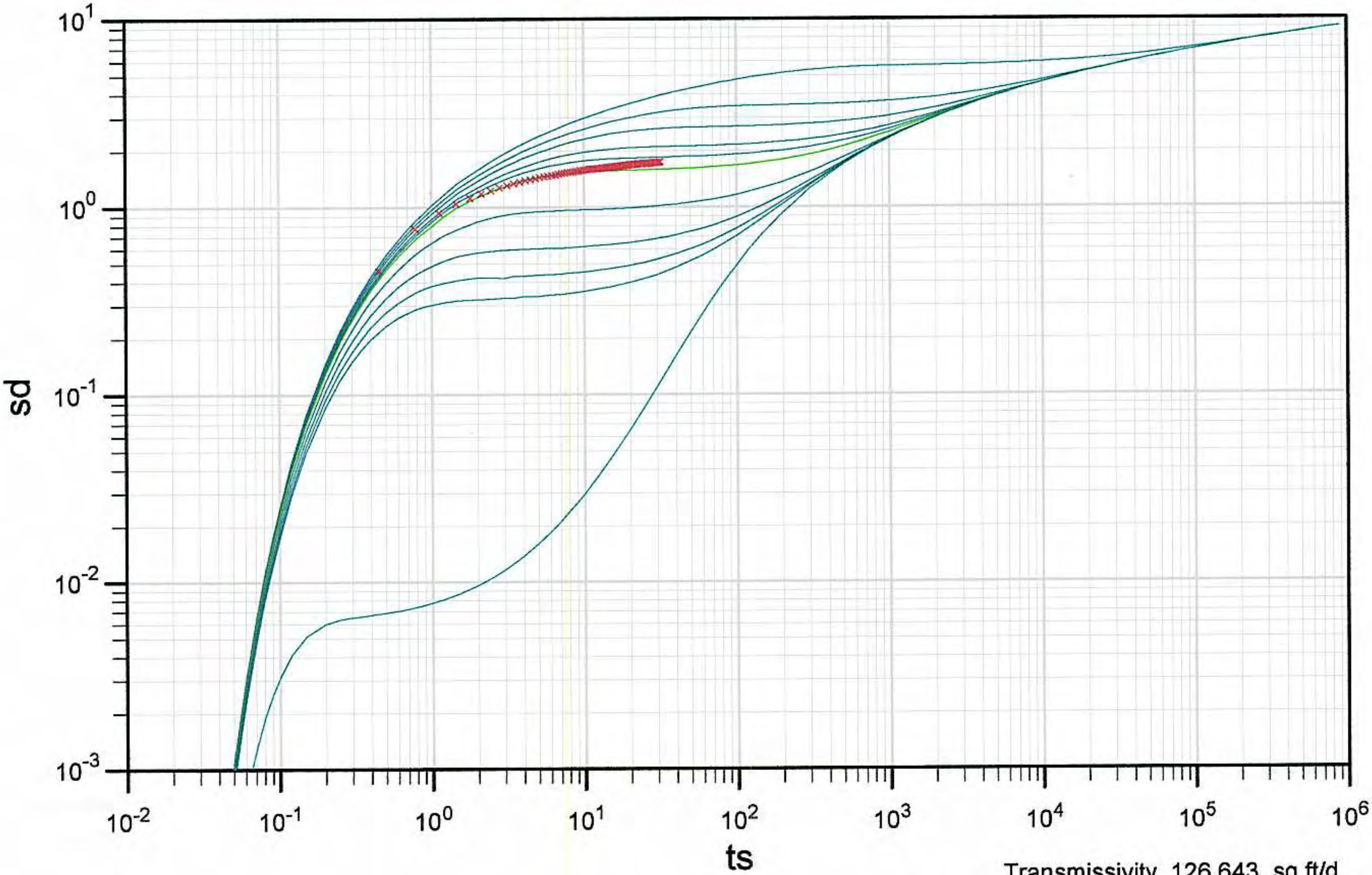
Transmissivity 95.3147 sq ft/d

PZ-01D - Hantush,1955 (Leaky Aquifer)



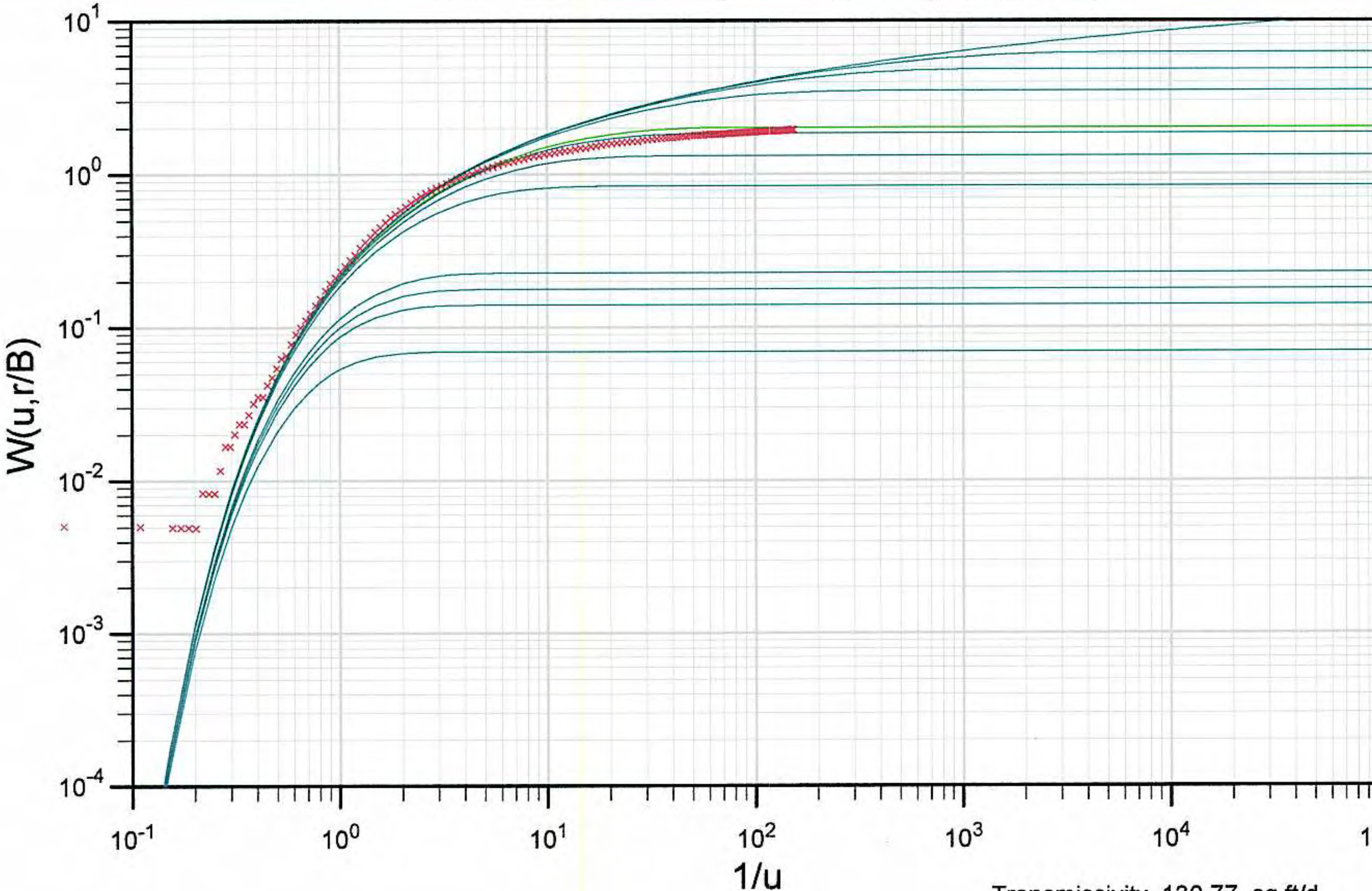
Transmissivity 145.874 sq ft/d

PZ-01D- Neuman, 1972 (Unconfined Aquifer)



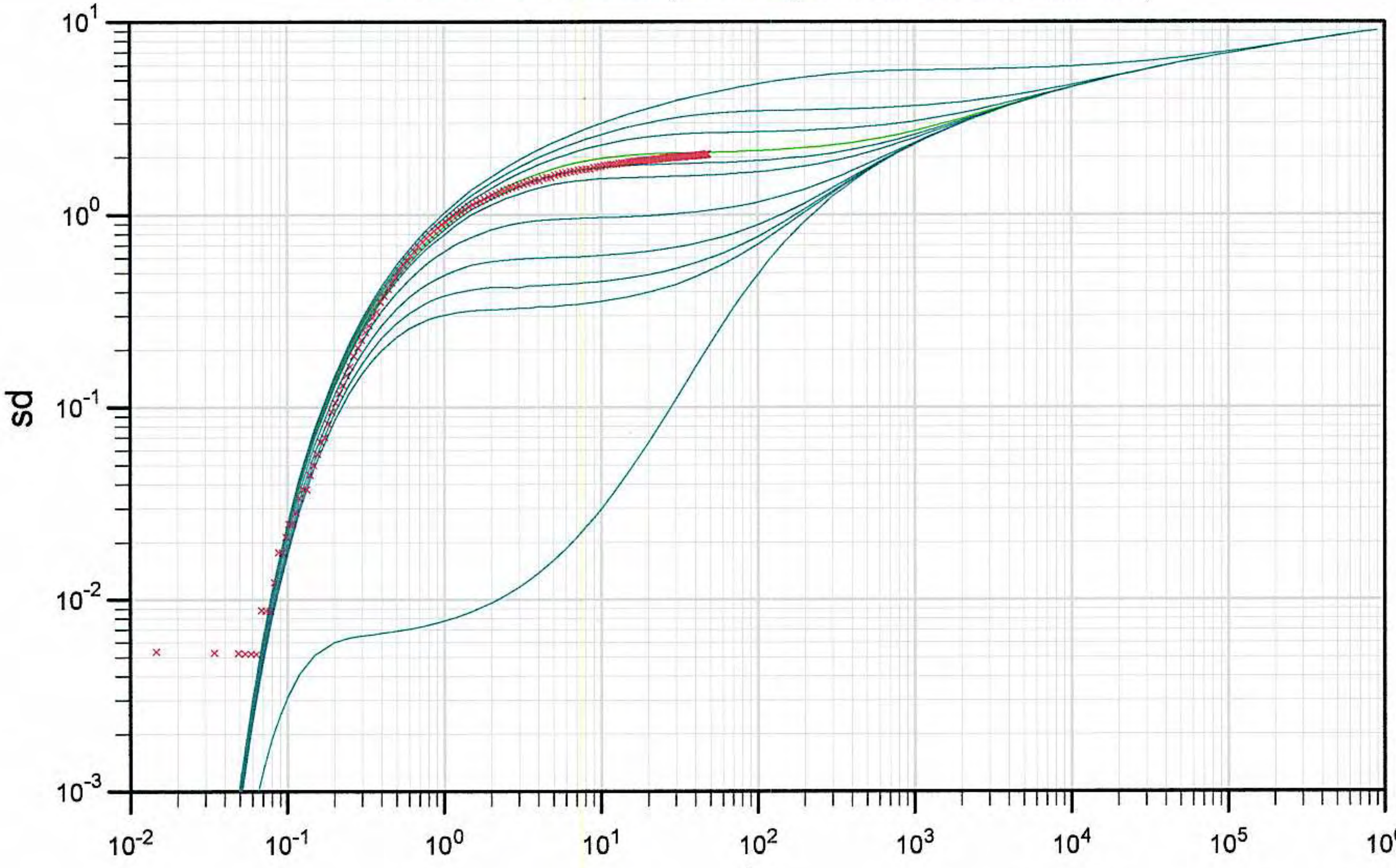
Transmissivity 126.643 sq ft/d

PZ-02D - Hantush, 1955 (Leaky Aquifer)



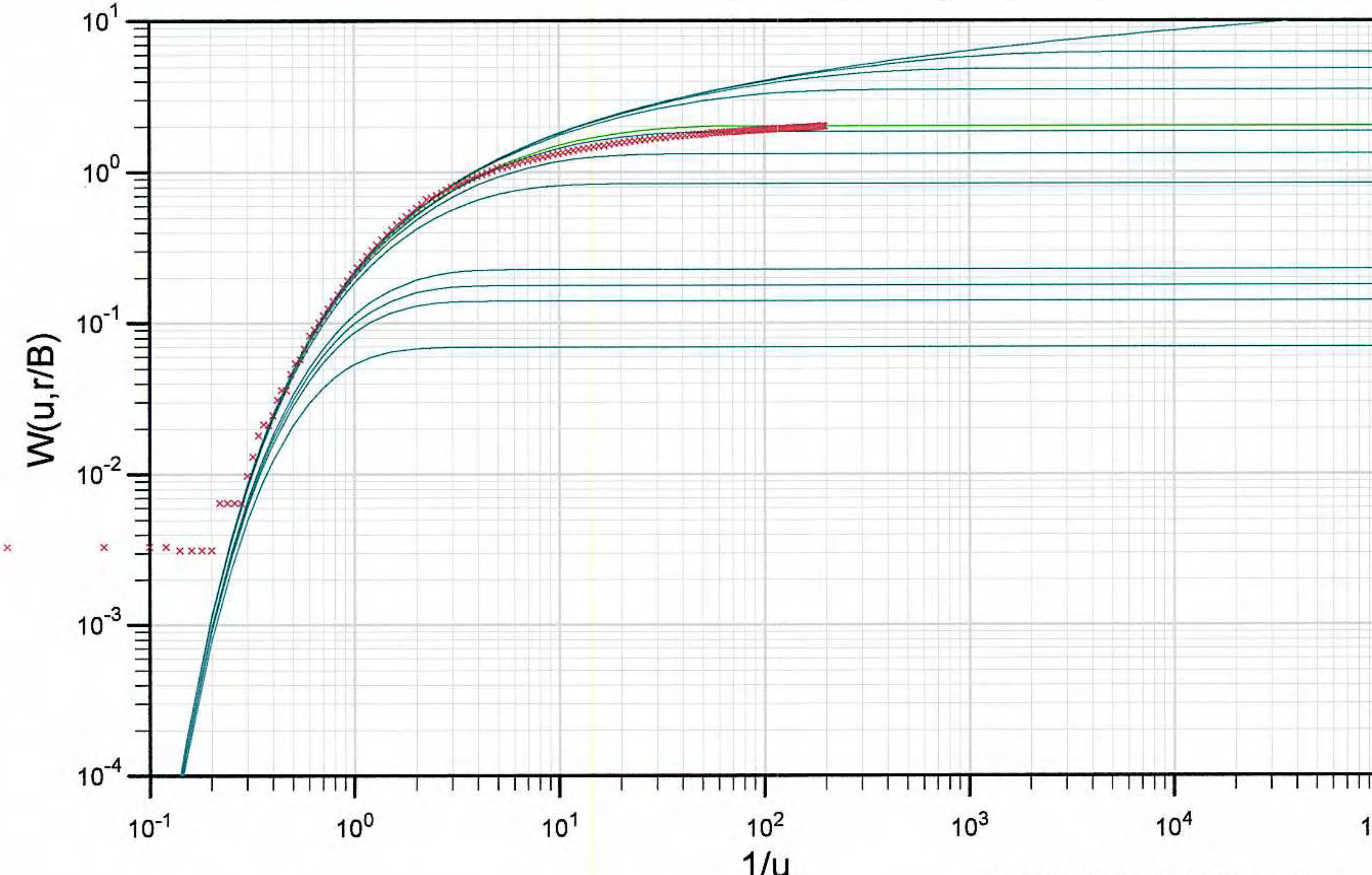
Transmissivity 130.77 sq ft/d

PZ-02D - Neuman, 1972 (Unconfined Aquifer)



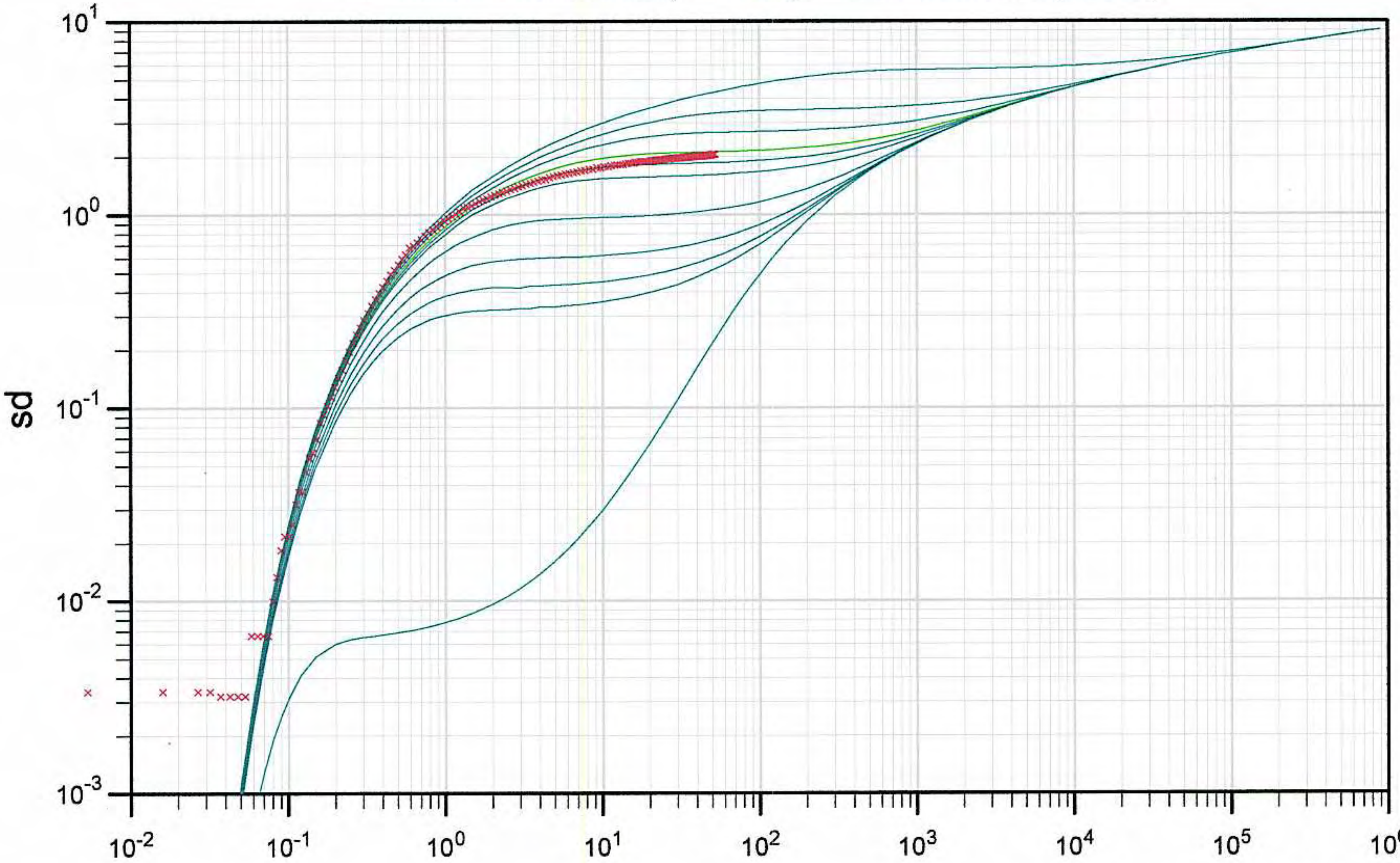
Transmissivity 138.215 sq ft/d

PZ-03D - Hantush, 1955 (Leaky Aquifer)



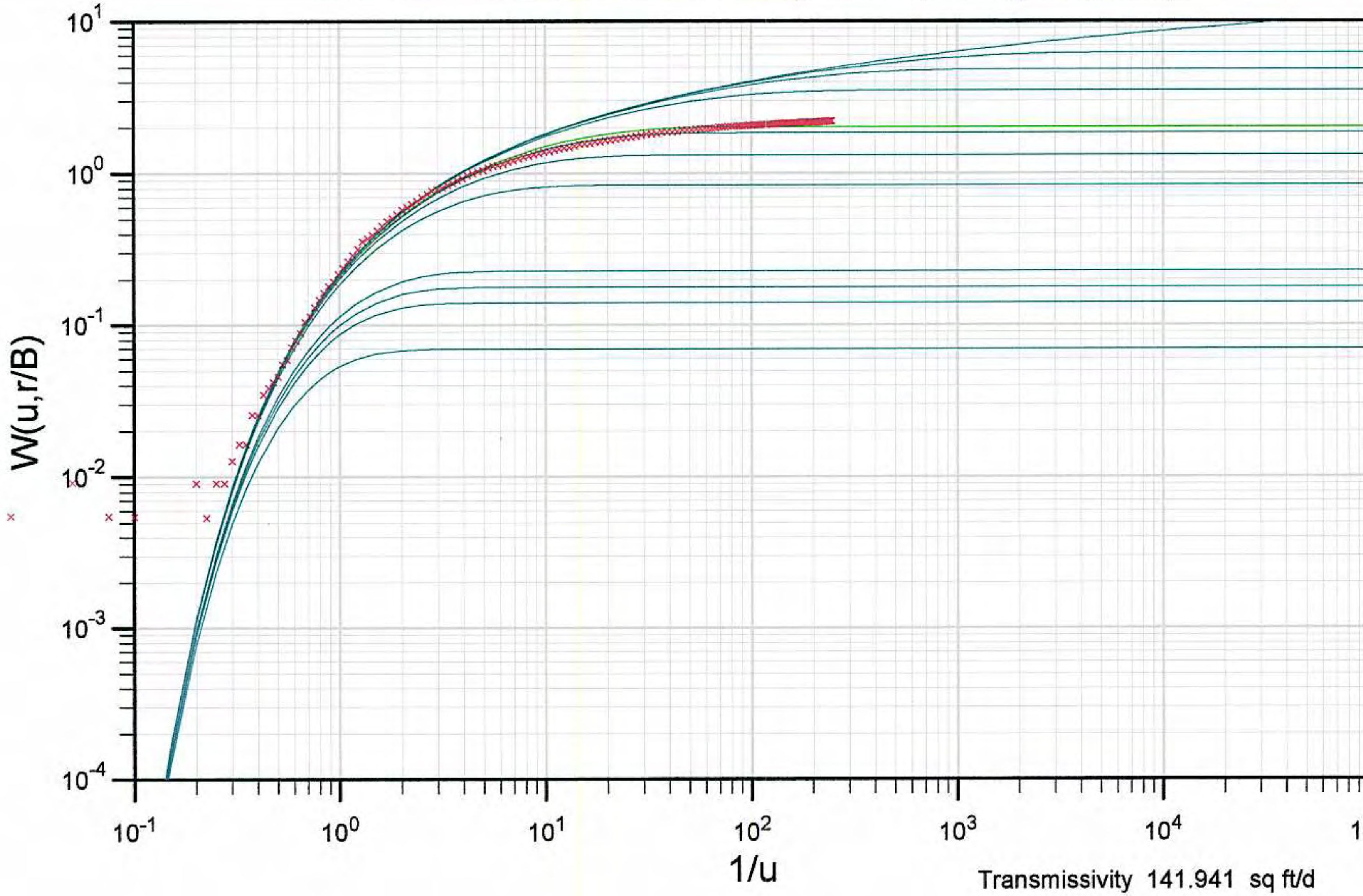
Transmissivity 127.245 sq ft/d

PZ-03D - Neuman, 1972 (Unconfined Aquifer)



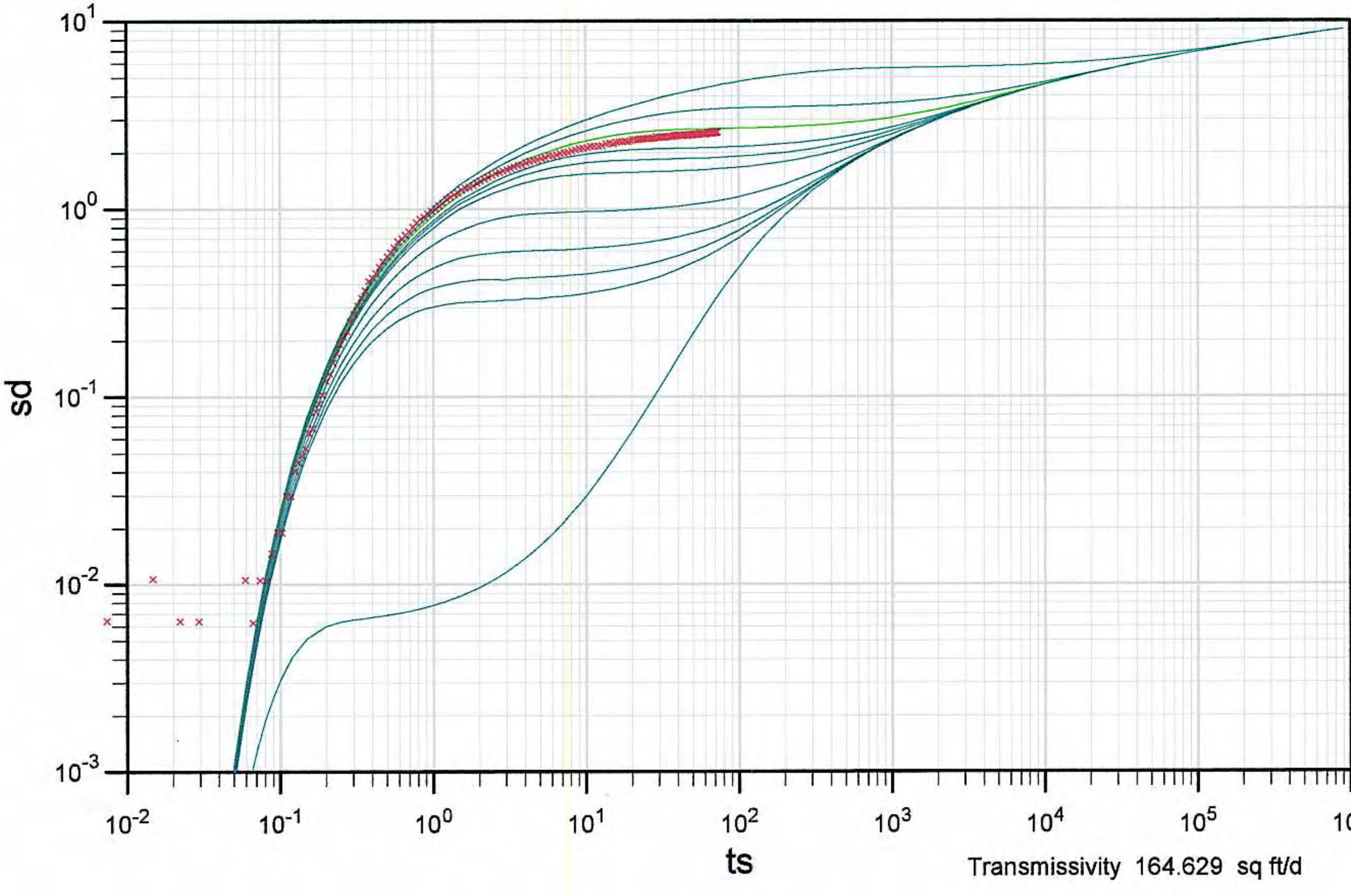
Transmissivity 129.442 sq ft/d

PZ-04D Hantush and Jacob, 1955 (Leaky Aquifer)



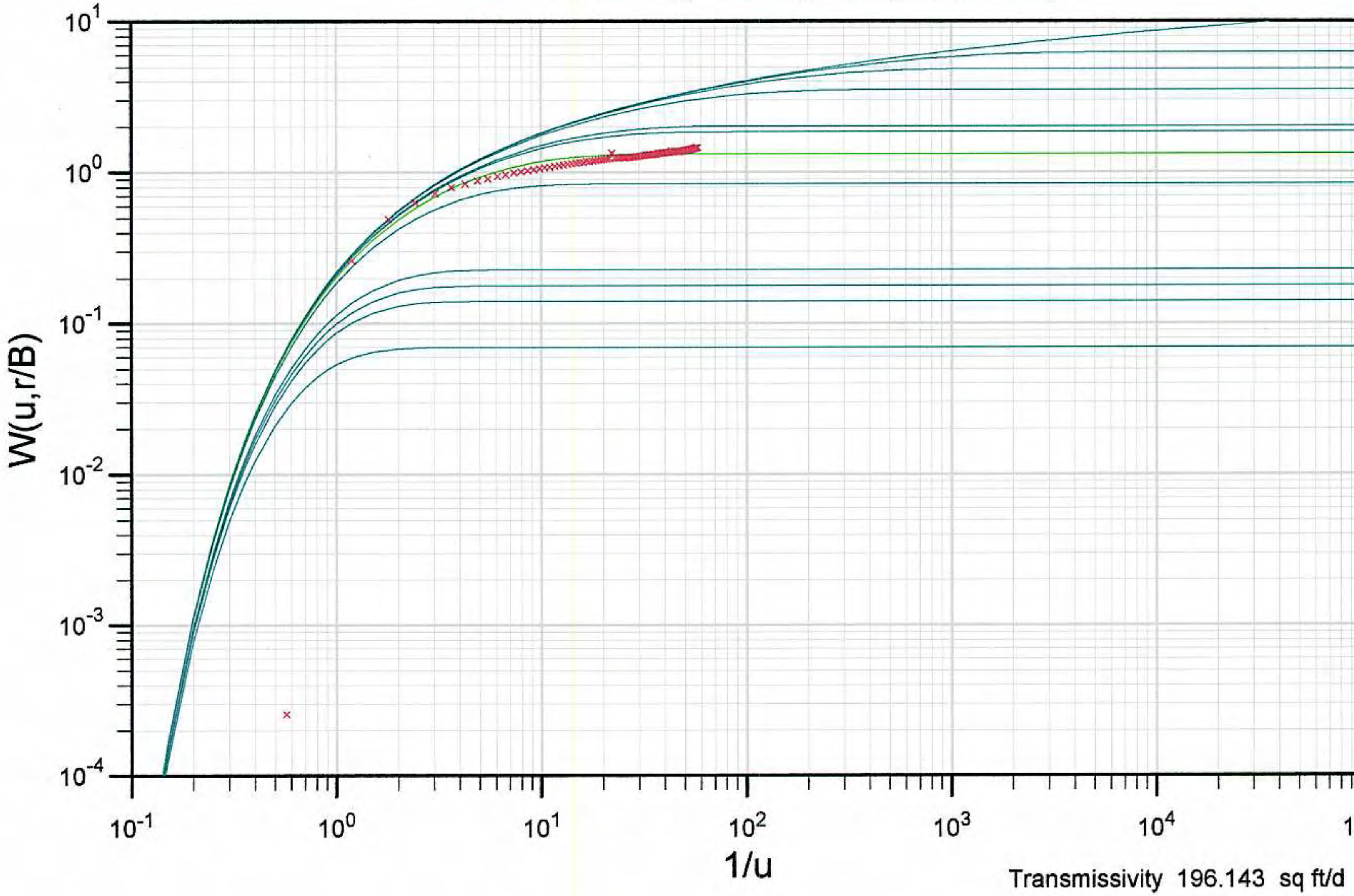
Transmissivity 141.941 sq ft/d

PZ-04D - Neuman, 1972 (Unconfined Aquifer)



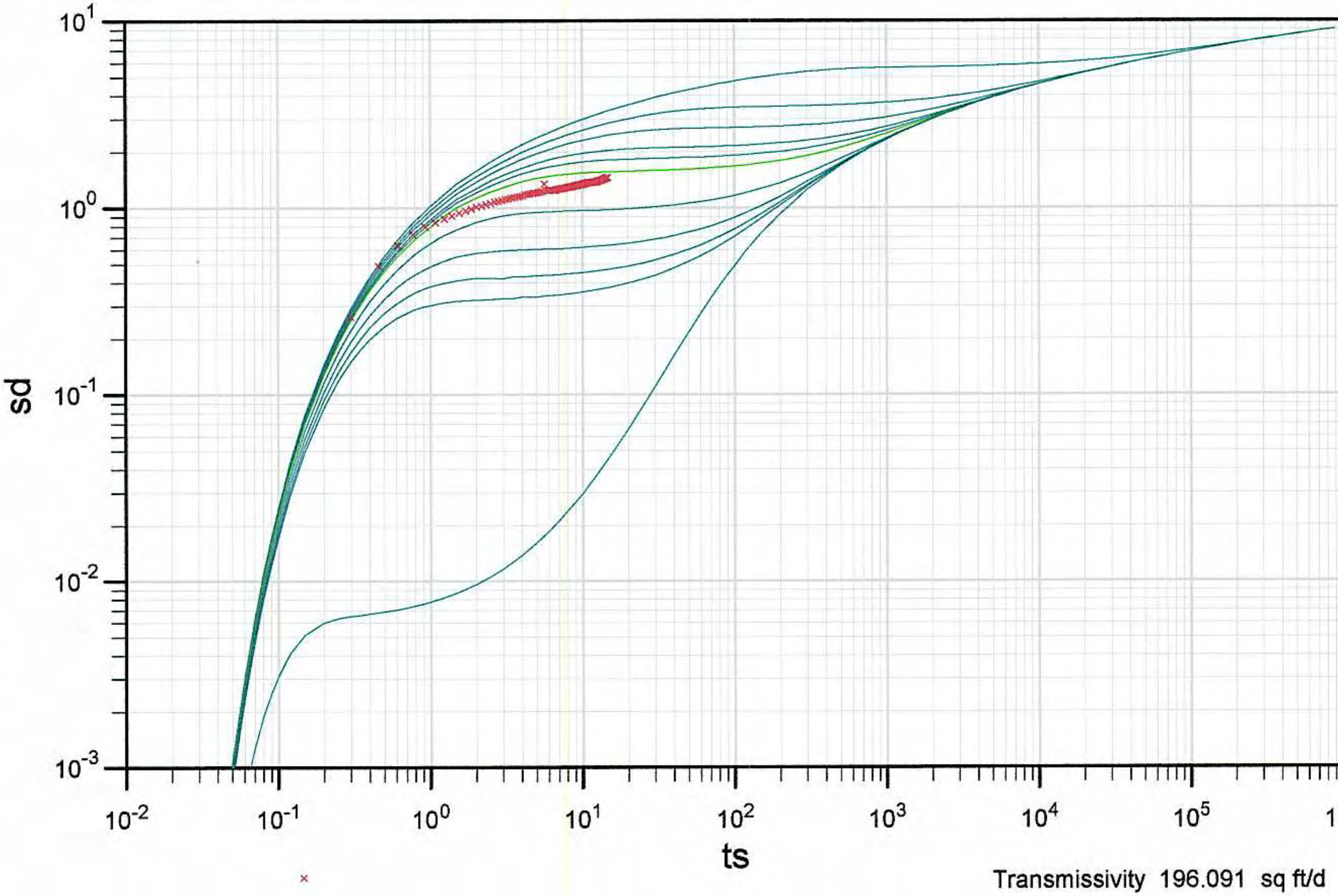
Transmissivity 164.629 sq ft/d

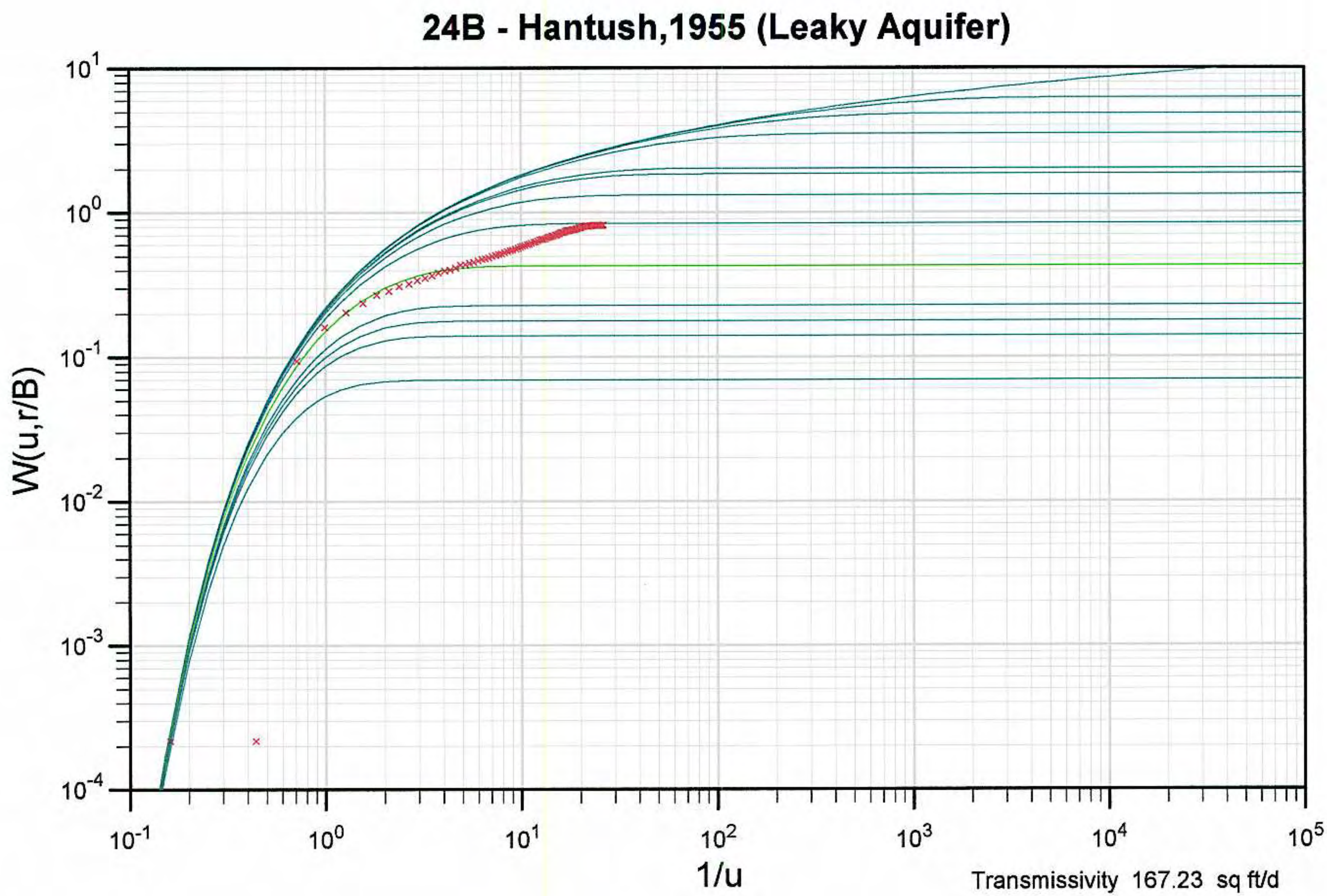
32D - Hantush, 1955 (Leaky Aquifer)



Transmissivity 196.143 sq ft/d

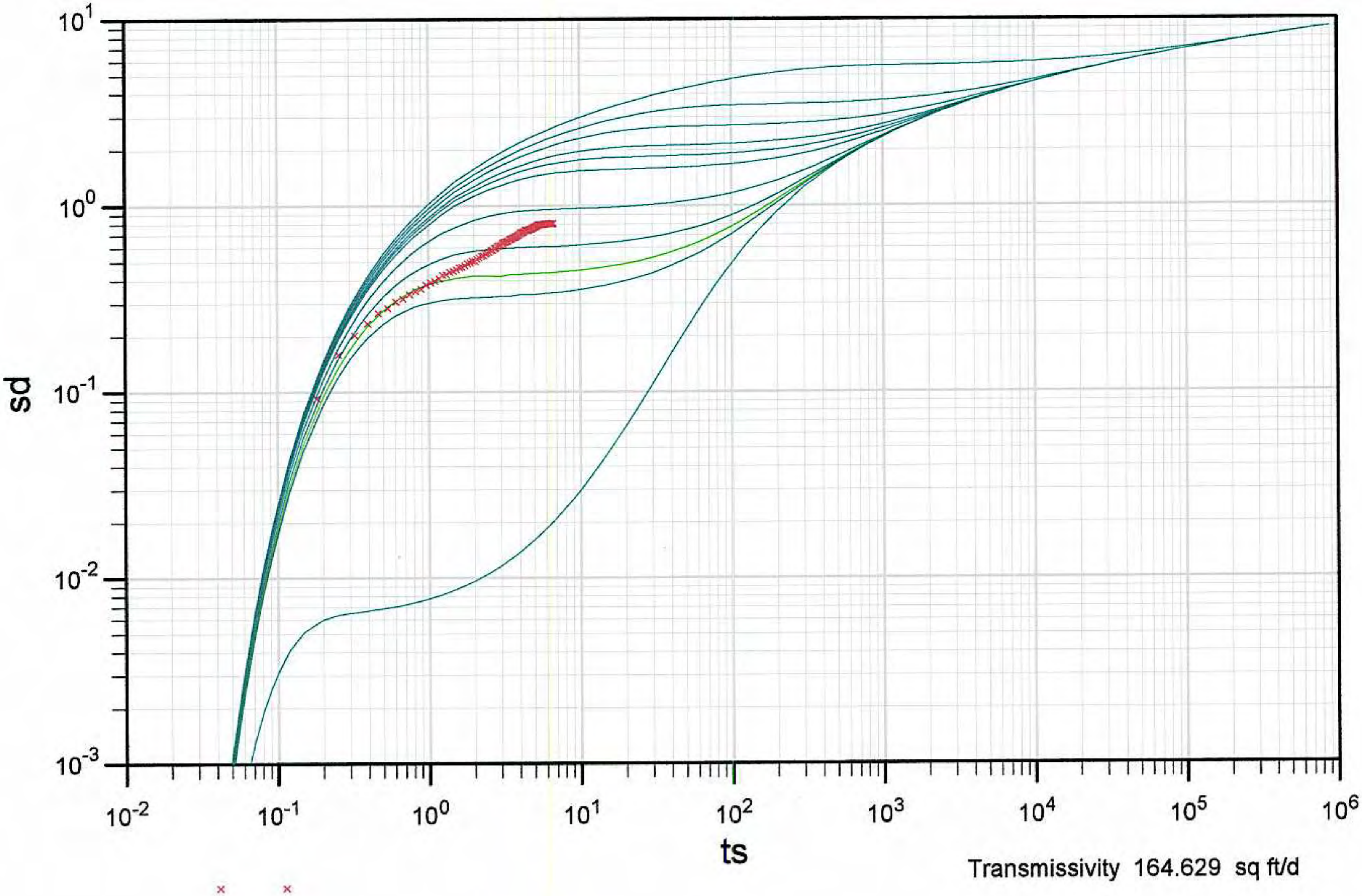
32D- Neuman, 1972 (Unconfined Aquifer)





24B - Hantush,1955 (Leaky Aquifer)
W(u,r/B)
10^1
10^0
10^-1
10^-2
10^-3
10^-4
10^-1
10^0
10^1
10^2
10^3
10^4
10^5
1/u
Transmissivity 167.23 sq ft/d

24B - Neuman, 1972 (Unconfined Aquifer)



Orlando Naval Training Center Study Area 17 (SA-17) Preliminary Remediation System Modeling Summary

PREPARED FOR: CH2M HILL/ATL

PREPARED BY: CH2M HILL/TPA

COPIES:

DATE: September 28, 2005

This technical memorandum summarizes the modeling effort for the Orlando, Florida Navy Training Center Study Area 17 (SA-17). Aquifer testing was conducted by CH2MHILL to confirm aquifer characteristics and provide local hydrogeologic parameters that will assist in the design of a ground water remediation system for the treatment of dissolved Chlorinated Volatile Organic Compounds (CVOCs).

Tables and Figures are located at the end of the report in the order they are referenced. Attachments follow the Tables and Figures.

Background

The Navy Training Center SA-17 is located west of the Orland International Airport. The location of the site is shown in Figure 1. The CVOC contamination at SA-17 is within the surficial aquifer. The site will be remediated by injecting emulsified oil substrate around the outer perimeter of contamination plume while pumping from a recovery well located in the center of the plume to maintain a gradient towards the contamination area. The purpose of this modeling effort is to assist with the design of the remediation system by providing insight to the potential aquifer response to the pumping and injection activities.

The surficial aquifer at SA-17 exists to approximately 50 feet bls and consists primarily of sand with intermittent layers of low porosity silty sand. The sub-surface has been delineated into different zones based on semiconfinment layers that exist within the aquifer. For the purpose of this model simulation, the aquifer is divided into two layers. The first (top) layer represents zones A and B. Layer 2 represents zone C. The bottom of layer 2 is assumed to be impermeable. Layer 1 extends from 0 to 25 feet and layer 2 from 25 to 50 feet bls. The water table is assumed to be at 0 feet. A thin layer of semi-confining silty sand separates Zone C from Zones A and B.

A constant rate pumping test was conducted at OLD Well 17 –MW 51C on August 16, 2005. The pumped well is a 2-inch diameter well screened from 42 to 47 feet bls (Zone C). Eight new 1-inch diameter PVC peizometers were constructed prior to the pump test to be used as monitoring wells (PZ-01S, PZ02S, PZ-03S, PZ-04S, PZ-01D, PZ-02D, PZ-03D, and PZ-04D). The peizometers designated with an "S" (shallow) are complete with a screen interval from 20-21 feet bls (Zone B). The "D" (deep) wells are completed with screened intervals from 35-36 feet bls (Zone C).

The data was analyzed and the following average aquifer parameters were estimated:

- Transmissivity of 1,050 gpd/ft (140 ft2/d) (Zone C)
- Storativity of 0.016
- Hydraulic Conductivity of 5.6 ft/d (Zone C)

Groundwater Modeling

Initially, a 2-dimensional (2D) model WinFlow32 (by ESI) was intended to be used to simulate the constant rate aquifer performance test. However, based on the observation well responses observed in the field, it was apparent that there is a hydraulically restricting unit between Zones B and C since zone B and C wells located 10 feet away from the pumping well had significantly different drawdowns. From this information it was decided to complete the modeling using a 3-D model which can simulate distinct layers and provide travel times.

The pump test estimated parameters were used as input for the 2-D model. The model predicted that the drawdown in the 2-inch diameter pumped well should be approximately 16 feet for a flow rate of 5 gpm. The observed drawdown in this well during the pump test was 30 feet. The differences in these drawdowns can be severe head losses due to the pumping well is not being fully developed (to it's maximum potential), or that the aquifer around the well has reduced permeability of some sort from previous treatment, or naturally (a silty envelope around the screened portion that cannot be developed out).

Three-Dimensional Modeling Results

MODFLOW, a numerical groundwater modeling program developed by the U.S. Geological Survey (USGS), was used to estimate the effects of pumping and injection activities from the proposed remediation system.

Model Calibration to Pump Test Data

The model was first calibrated by matching the drawdown effects from the SA-17 aquifer performance test. Five new piezometers were used to match the model simulation to observed water levels during the pump test. Table 1 lists the wells used in the model pump test match simulation, the simulated water levels, and the observed water levels during the pumping test.

The observed results in layer 2 were difficult to match. This could be indicative of changes in aquifer parameters in localized areas.

Remediation System Operation Simulations

The 3-D model was used to simulate the injection of the emulsified oil substrate into 4 perimeter injection wells located 50 feet apart. In the middle if these wells will be a 4-inch diameter pumping (extraction) well. Each layer will have the identical remediation system except with different well depths to target Zone A/B or C. The model simulations assume continuous operation of the injection and extraction wells. The injection rates are simulated for 1 and 3 gpm. The extraction well was only simulated at a withdrawal rate of 5 gpm. Groundwater drawdown/mounding contours are presented in the attachments. Table 2 lists the simulation results.

Table 1
MODFLOW Simulation Calibration Results
US Navy SA-17 Preliminary Remediation Modeling Summary

Well Name	Zone and Model Layer	Distance from Pumped Well (feet)	Observed Drawdown (feet)	Simulated Drawdown (feet)
24B	1 and B	10.85	0.38	0.36
34D	1 and B	15.12	0.50	0.33
I30	1 and B	24.67	0.24	0.24
PZ-01D	2 and C	21.17	1.06	0.80
PZ-02D	2 and C	10.3	1.15	1.57

Table 2
MODFLOW Simulation Summary
US Navy SA-17 Preliminary Remediation Modeling Summary

Simulation	Injection Well mounding* (feet)	Extraction Well Drawdown (feet)	Comments
Layer 1			
Inject 1 gpm in 4 wells Withdrawal 5 gpm in 1 well	-0.9 feet	8.21 feet	Reached in 7 days
Inject 3 gpm in 4 wells Withdrawal 12 gpm in 1 well	-4.3 feet	>25 feet (dry)	Reached in 20 days
Layer 2			
Inject 1 gpm in 4 wells Withdrawal 5 gpm in 1 well	-0.9 feet	7.05 feet	Reached in 7 days
Inject 3 gpm in 4 wells Withdrawal 12 gpm in 1 well	-4.8 feet	5.33 feet	Reached in 4 days – evidence of downward movement of water from layer 1 to layer 2.

*injection well water levels (negative) denote above static water level.

Stream Line and Particle Tracking Assessment

The simulation used the particle tracking method to show the bulk ground water flow direction each particle would take to reach the extraction well. The simulation plots show the groundwater contours for the operating system (in 0.1-foot increments). In these simulations, 20 particles were released in the cell of each injection well. The plots show the path lines taken for each particle based on the calculated groundwater flow velocity and the groundwater gradient. These plots are separated into two simulations for injection rates of 1 gpm and 3 gpm in each layer.

Simulation 1 – Four Injection Wells at 1 gpm and Extraction Well at 5 gpm

This simulation incorporated a total injection rate of 4 gpm split between 4 injection wells and a single extraction well pumping at 5 gpm. Both layers have identical remediation systems. The results show the travel time for the substrate from all of the 1 gpm injection wells to reach the extraction well in layer 1 occurred in 7 days (168 hours) of continuous operation. The results show the travel time for the substrate from all of the 1 gpm injection wells to reach the extraction well in layer 2 also occurred in 7 days (168 hours) of continuous operation.

Reviewing the 30 day operation particle trace plots of both layers for this simulation suggest that there may be an area of aquifer or contamination plume between each injection well that is unaffected by the injection wells at the injection rate of 1 gpm. If this is the case, it may be difficult to assume that the substrate has been uniformly distributed throughout the aquifer. Additional wells may need to be installed to provide better coverage of the substrate application. With an injectate of 1 gpm, the hydraulic gradient from the extraction well (each at 5 gpm) remains adequate to capture all injected substrate towards the direction of the extraction well. The groundwater velocity vector plots for each layer provide the extent of the impact the extraction well has on the injected substrate. The particle tracking plots are provided in Attachment A.

Simulation 2 – Four Injection Wells at 3 gpm and Extraction Well at 12 gpm

This simulation incorporated a total injection rate of 12 gpm split between 4 injection wells and a single extraction well pumping at 12 gpm. Both layers have identical remediation systems. The results show the travel time for the substrate from all of the 3 gpm injection wells to reach the extraction well in layer 1 occurred in 20 days (480 hours) of continuous operation and the pumping well went dry. The results show the travel time for the substrate from all of the 3 gpm injection wells to reach the extraction well in layer 2 occurred in 4 days (96 hours) of continuous operation. The particle trace plots show that a majority of the injected substrate (approximately 60%) is not captured by the extraction well, however, the injection well does promote the migration of 30% of the substrate through the aquifer providing for adequate exposure of the aquifer material to the substrate. The groundwater velocity vector plots for each layer show that there is significant groundwater movement away from the extraction well. The particle tracking plots are provided in Attachment B.

Summary

With an injection rate of 1 gpm, the hydraulic gradient from the extraction wells (each at 5 gpm) remains adequate to capture all injected substrate towards the direction of the extraction well. Reviewing the 30 day operation particle trace plots of both layers for the 1 gpm injection rate simulation suggest that the substrate may not come in contact with the full extent of the contamination plume. If this is the case, it may be difficult to assume that the substrate has been uniformly distributed throughout the aquifer and provide the best conditions for natural attenuation. Additional wells may need to be installed to provide better coverage of the substrate application. The groundwater velocity vector plots for each layer provide the extent of the impact the extraction well has on the injected substrate.

Reviewing the 30 day operation particle trace plots of both layers for the 3 gpm injection rate simulation suggest that the hydraulic gradient from the extraction wells (each at 12 gpm) is capable of capturing approximately 30% of the simulated particles, representing injected substrate, towards the direction of the extraction well. This simulation does suggest that there is adequate substrate coverage in the aquifer material. The extraction well in layer 1 went dry in this simulation.

Conclusions

The injection rates need to be matched to the extraction rates in order to maintain the hydraulic control. If the extraction rates and injection rates are high, there will be wells that go dry and short circuiting between zones.

An injection rate of 1 gpm may not be enough to provide full area exposure to the substrate. Additional wells may be needed at this injection rate. A slightly higher injection rate is probably necessary with the 4 injection well system, however, any injection into wells in this shallow aquifer will need to be made under pressure conditions since there will be water level mounding occurring.

Further modeling can be done which will provide insight on whether an injection phase should be separated from the pumping phase in oder to improve on the substrate coverage.

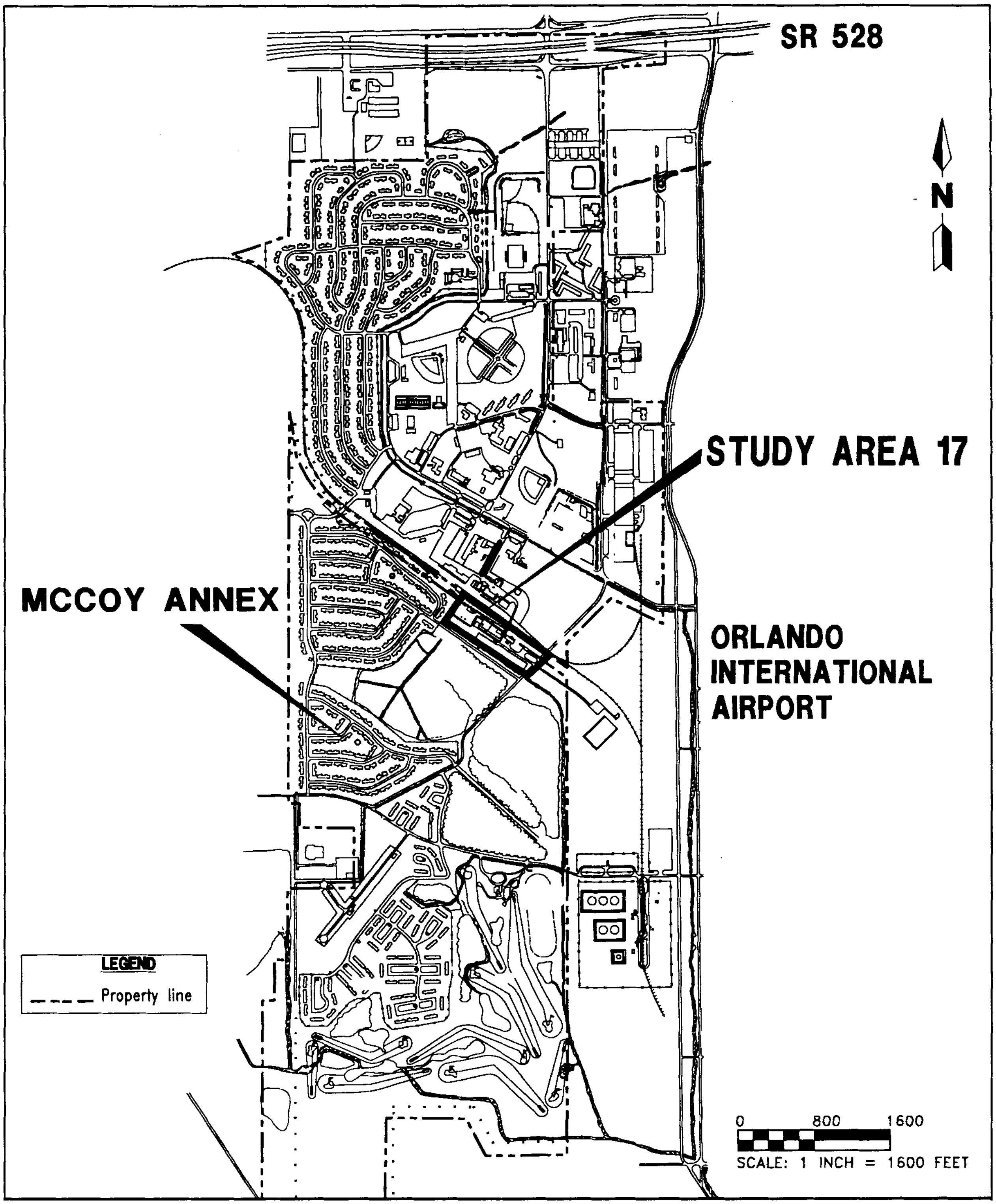


FIGURE 1
Site Plan
Aquifer Performance Test
Naval Training Center, Orlando, Florida
Study Area 17

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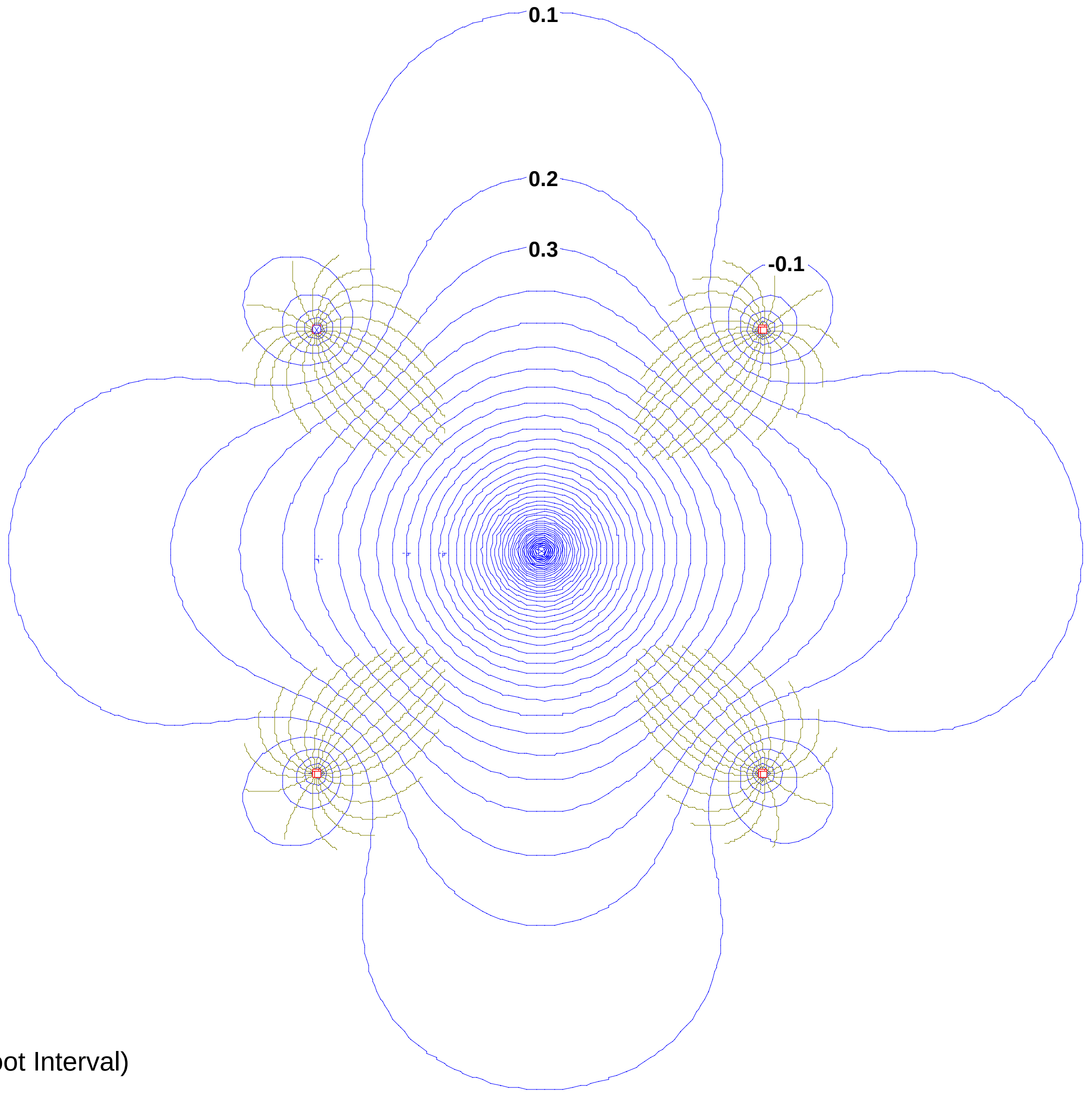
Attachment A

Particle Tracking Plots

Injection Rate 1 gpm
Extraction Rate 5 gpm
per layer



Layer 1 (Zone B)
Injection Rate = 1 gpm
Extraction Rate = 5 gpm
Time = 5 Days
Contours in Feet (0.1 Foot Interval)

FIGURE A.2
Preliminary Remediation System Model
Naval Training Center, Orlando, Florida
Study Area 17

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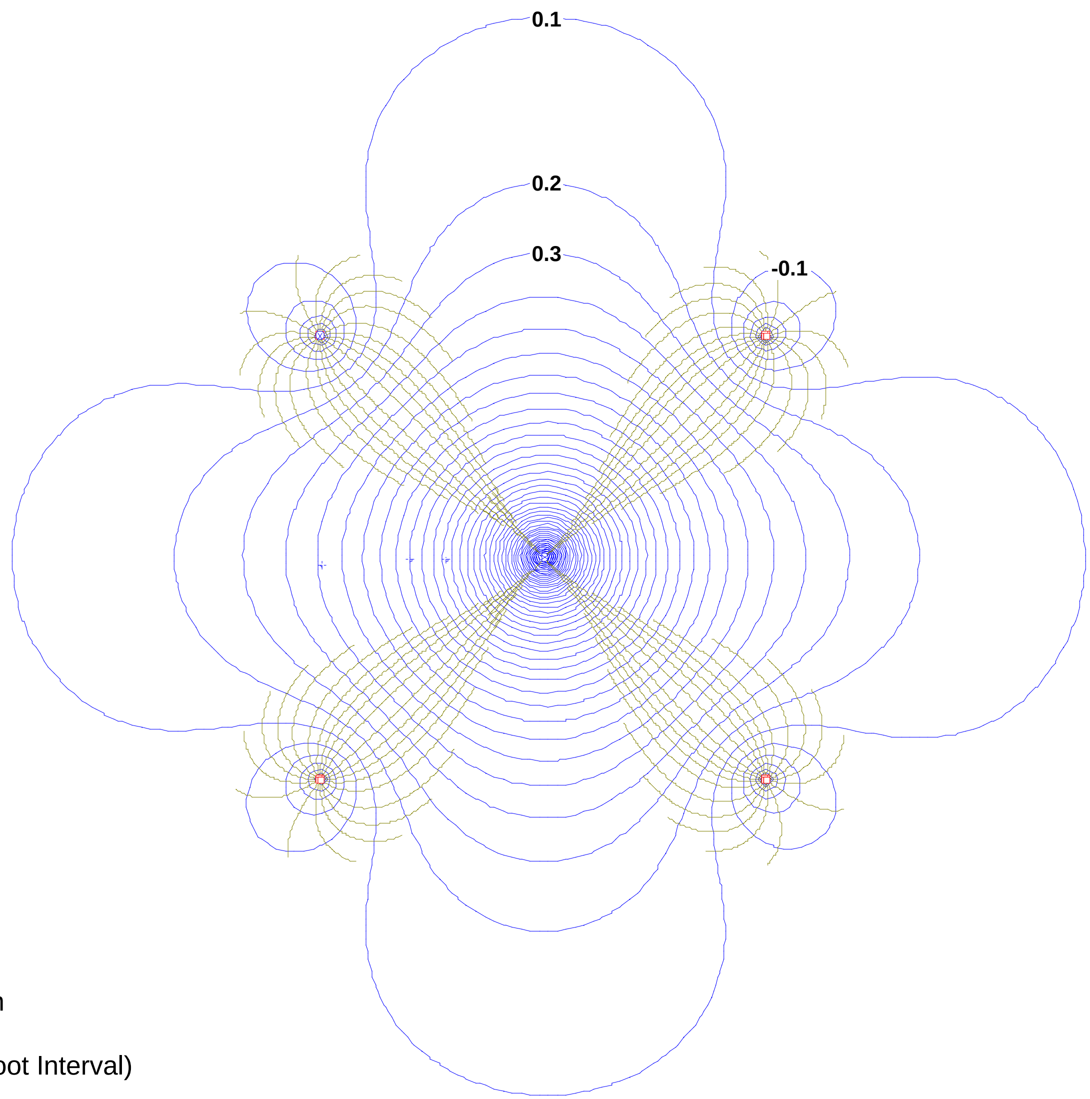
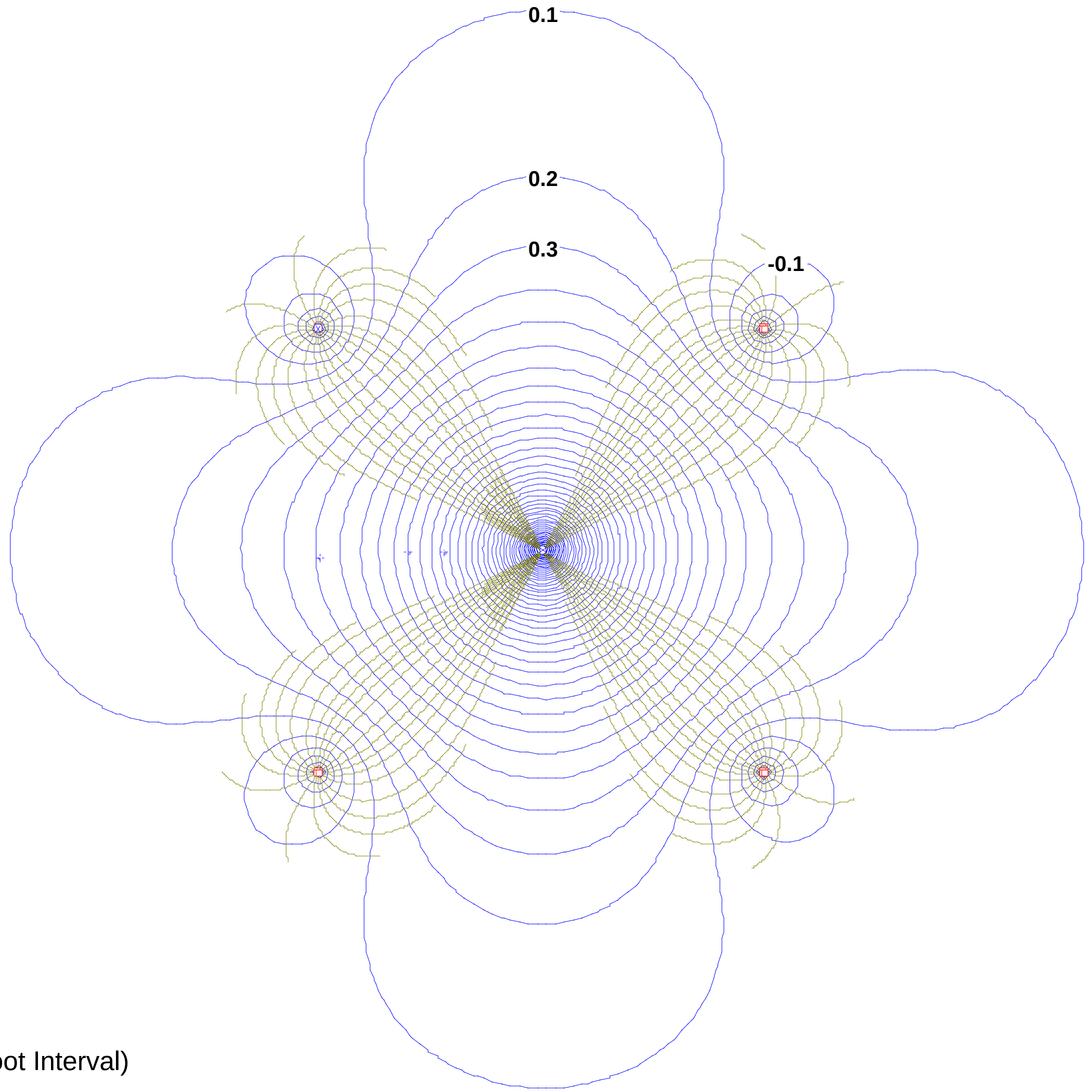


Layer 1 (Zone B)
Injection Rate = 1 gpm
Extraction Rate = 5 gpm
Time = 7 Days
Contours in Feet (0.1 Foot Interval)

FIGURE A.3
Preliminary Remediation System Model
Naval Training Center, Orlando, Florida
Study Area 17

CH2MHILL



Layer 1 (Zone B)
Injection Rate = 1 gpm
Extraction Rate = 5 gpm
Time = 10 Days
Contours in Feet (0.1 Foot Interval)

FIGURE A.4
Preliminary Remediation System Model
Naval Training Center, Orlando, Florida
Study Area 17

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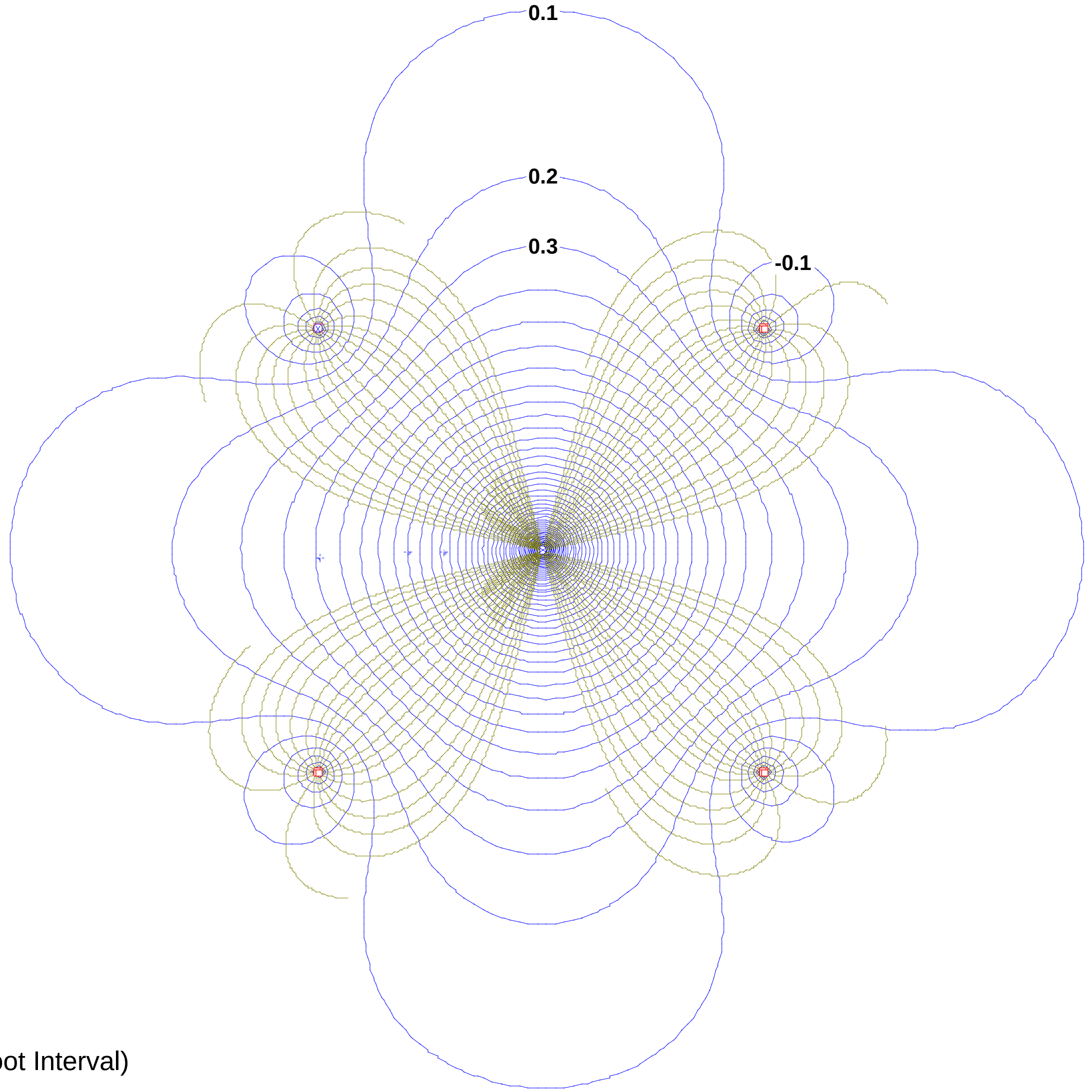

Layer 1 (Zone B)
Injection Rate = 1 gpm
Extraction Rate = 5 gpm
Time = 30 Days
Contours in Feet (0.1 Foot Interval)

FIGURE A.5
Preliminary Remediation System Model
Naval Training Center, Orlando, Florida
Study Area 17

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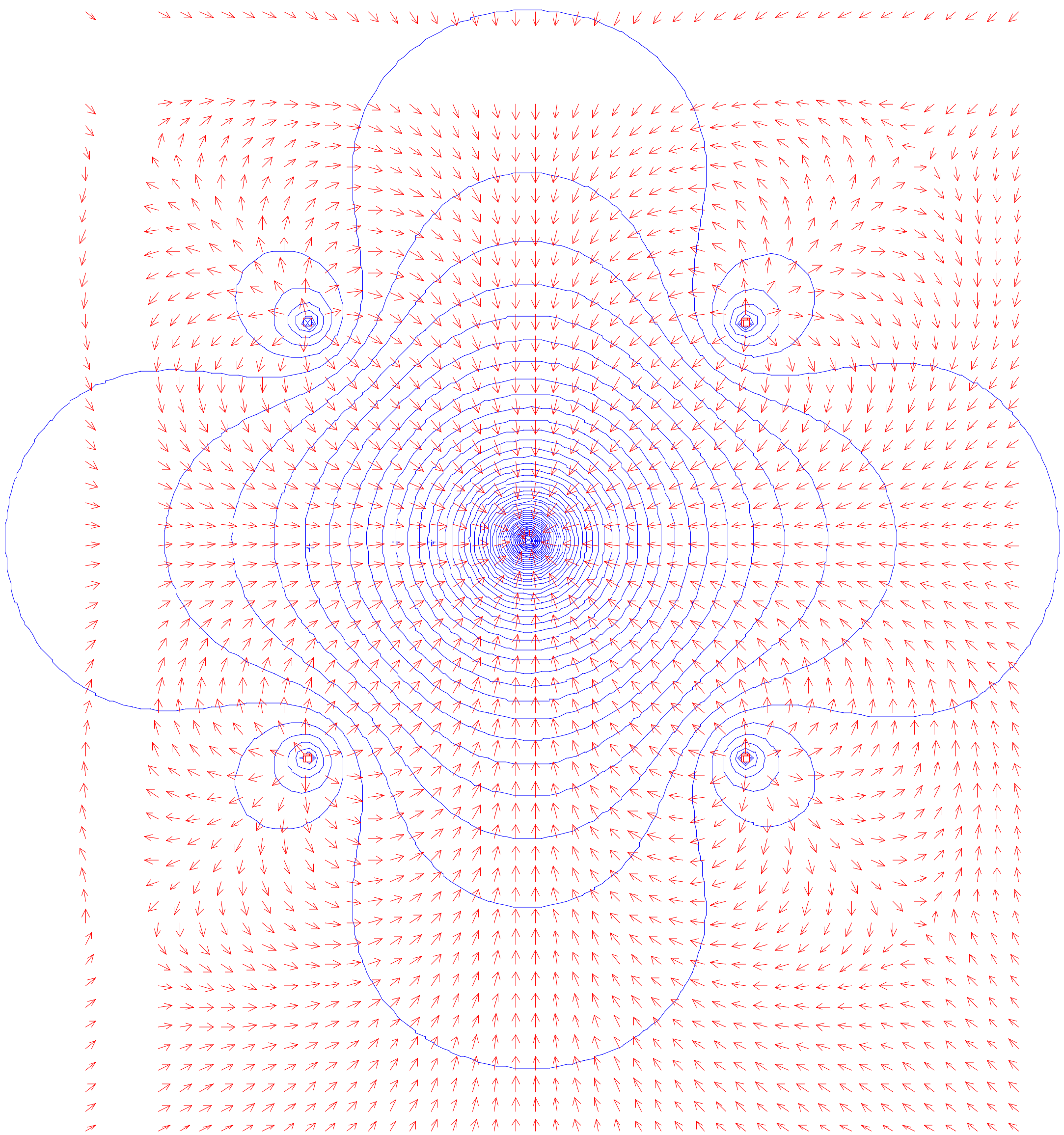

FIGURE A.6
Preliminary Remediation System Model
Naval Training Center, Orlando, Florida
Study Area 17

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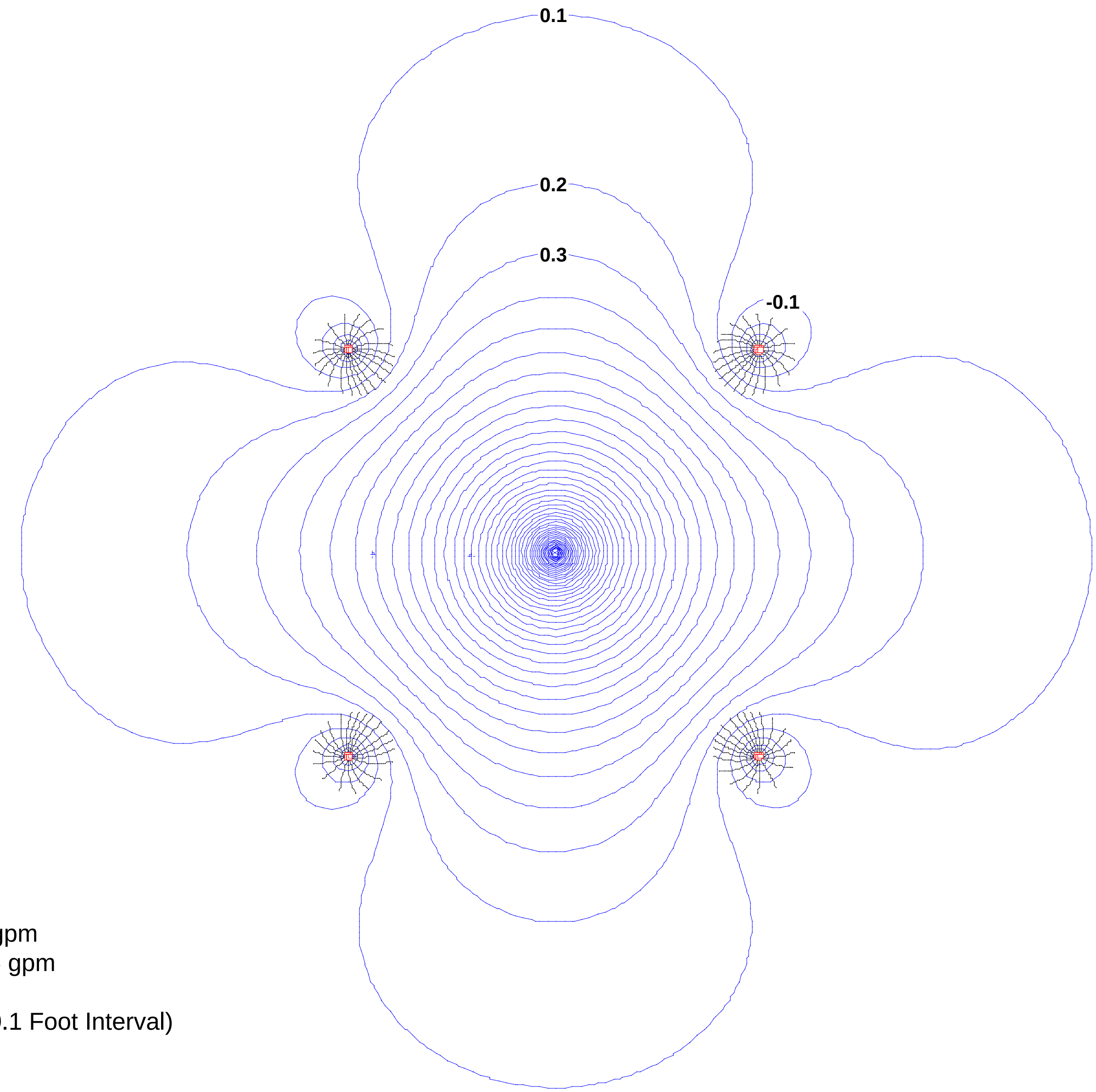

Layer 2 (Zone C)
Injection Rate = 1 gpm
Extraction Rate = 5 gpm
Time = 1 Day
Contours in Feet (0.1 Foot Interval)

FIGURE A.7
Preliminary Remediation System Model
Naval Training Center, Orlando, Florida
Study Area 17

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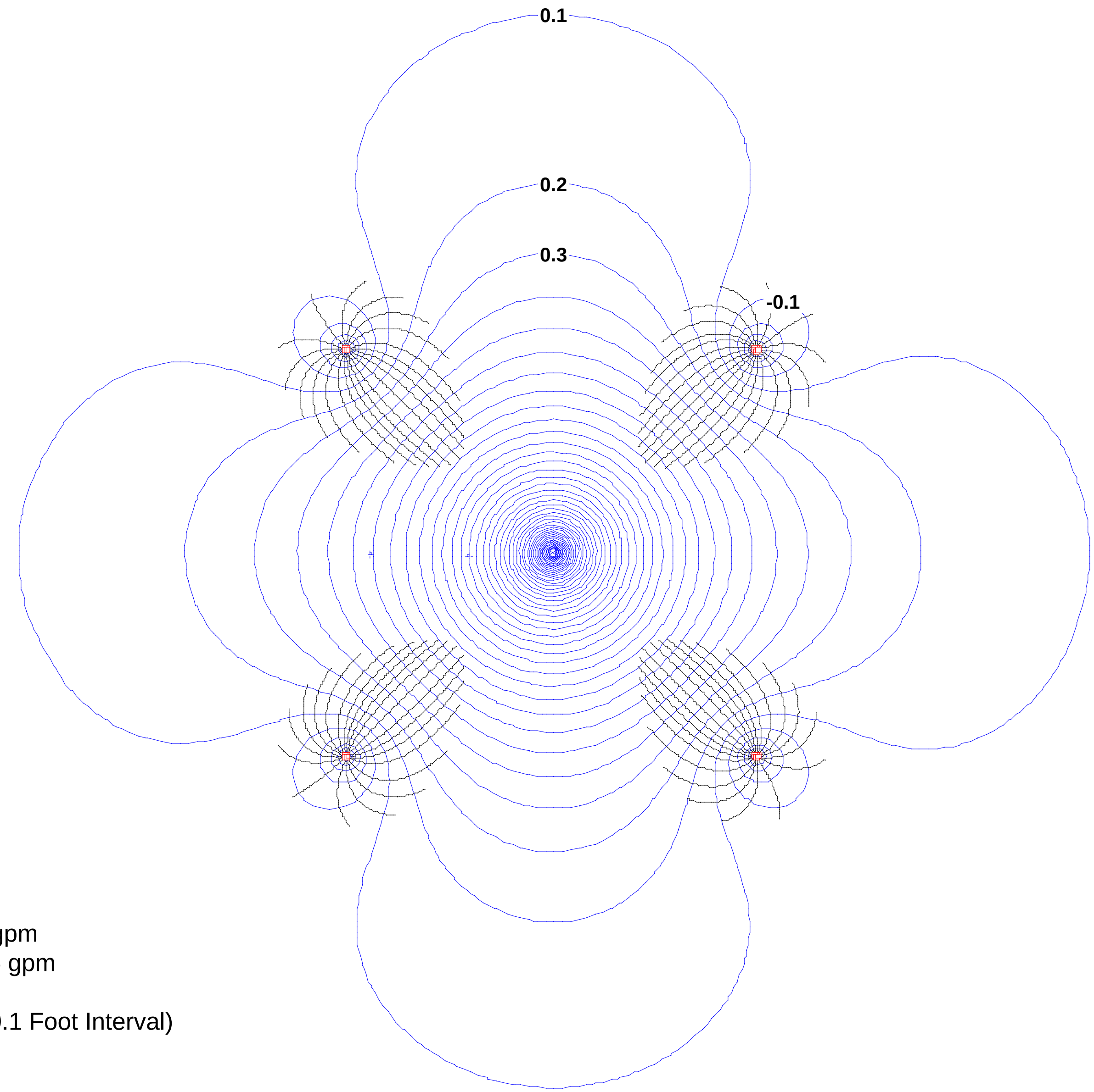
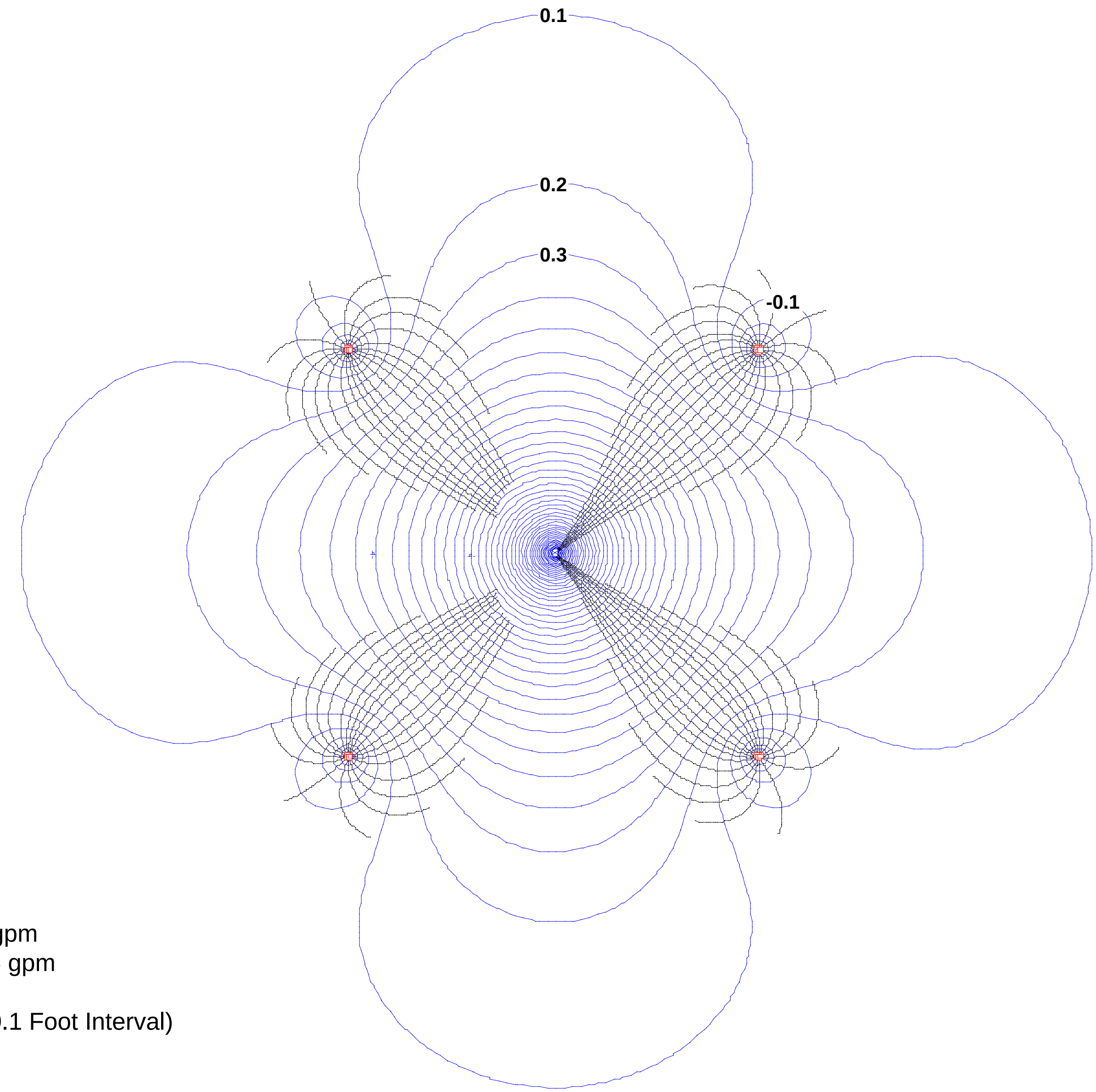


Layer 2 (Zone C)
Injection Rate = 1 gpm
Extraction Rate = 5 gpm
Time = 5 Days
Contours in Feet (0.1 Foot Interval)

FIGURE A.8
Preliminary Remediation System Model
Naval Training Center, Orlando, Florida
Study Area 17

CH2MHILL



Layer 2 (Zone C)
Injection Rate = 1 gpm
Extraction Rate = 5 gpm
Time = 8 Days
Contours in Feet (0.1 Foot Interval)

FIGURE A.9
Preliminary Remediation System Model
Naval Training Center, Orlando, Florida
Study Area 17

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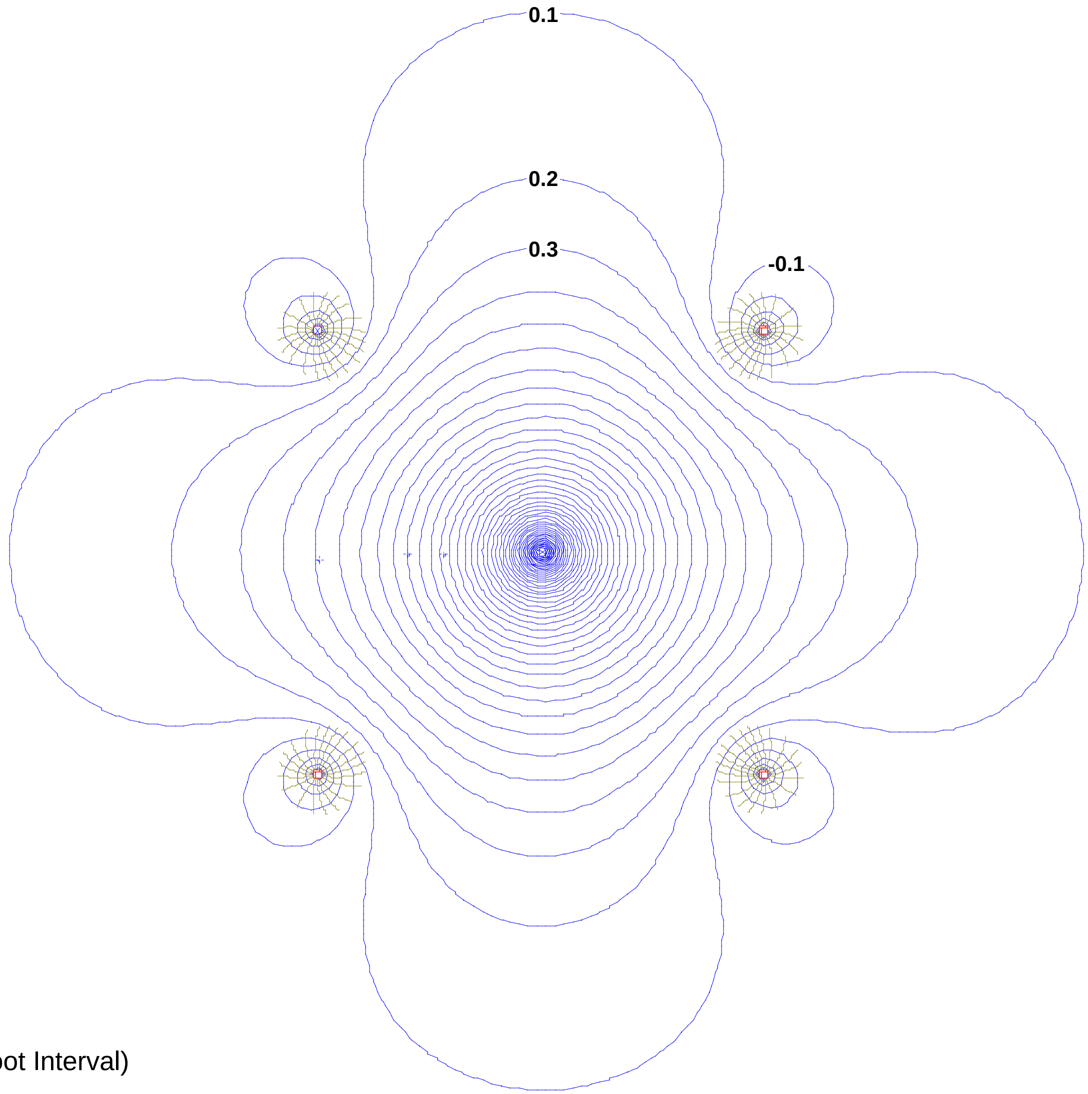
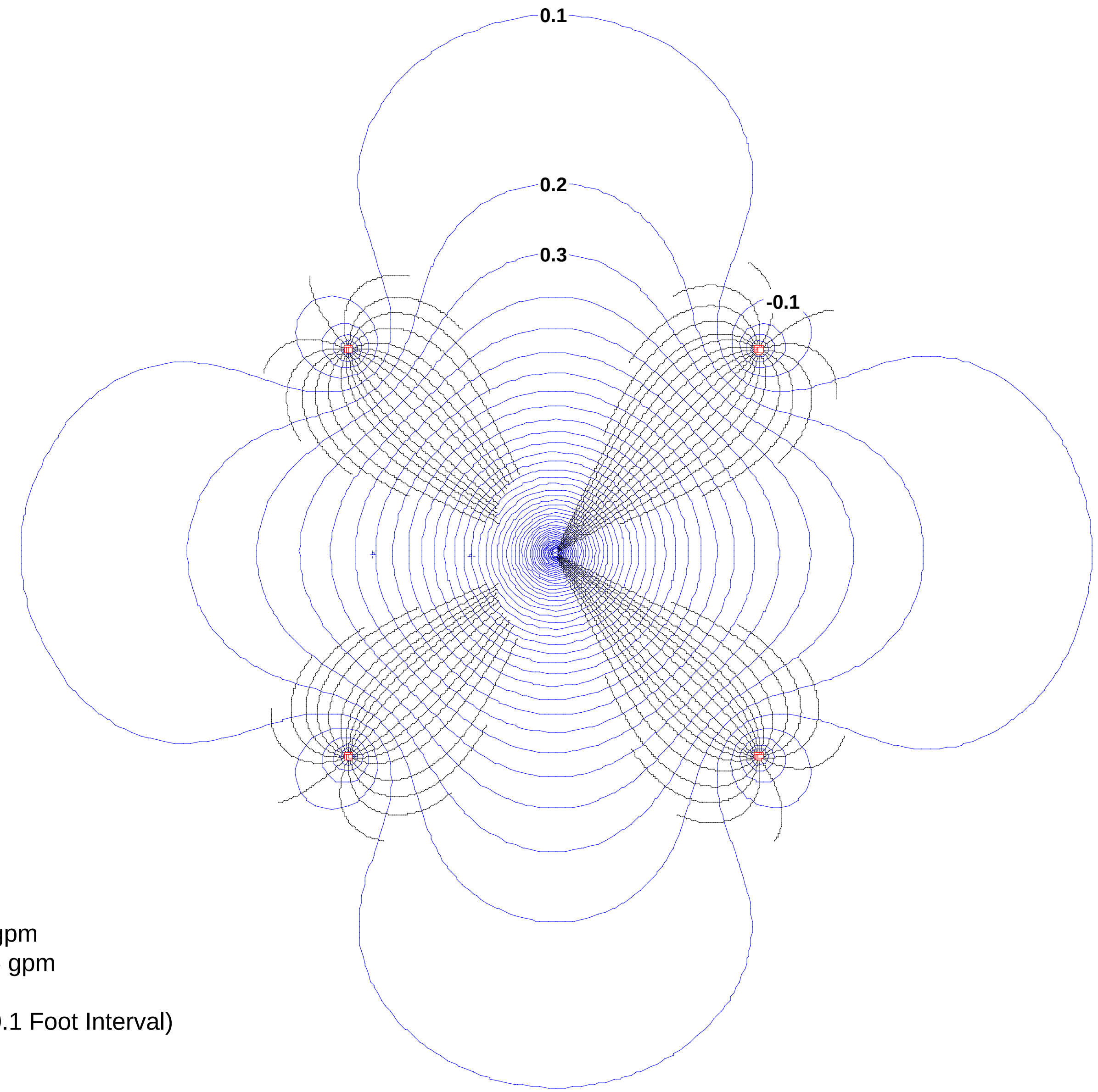


Layer 1 (Zone B)
Injection Rate = 1 gpm
Extraction Rate = 5 gpm
Time = 1 Day
Contours in Feet (0.1 Foot Interval)

FIGURE A.1
Preliminary Remediation System Model
Naval Training Center, Orlando, Florida
Study Area 17

CH2MHILL



Layer 2 (Zone C)
Injection Rate = 1 gpm
Extraction Rate = 5 gpm
Time = 10 Days
Contours in Feet (0.1 Foot Interval)

FIGURE A.10
Preliminary Remediation System Model
Naval Training Center, Orlando, Florida
Study Area 17

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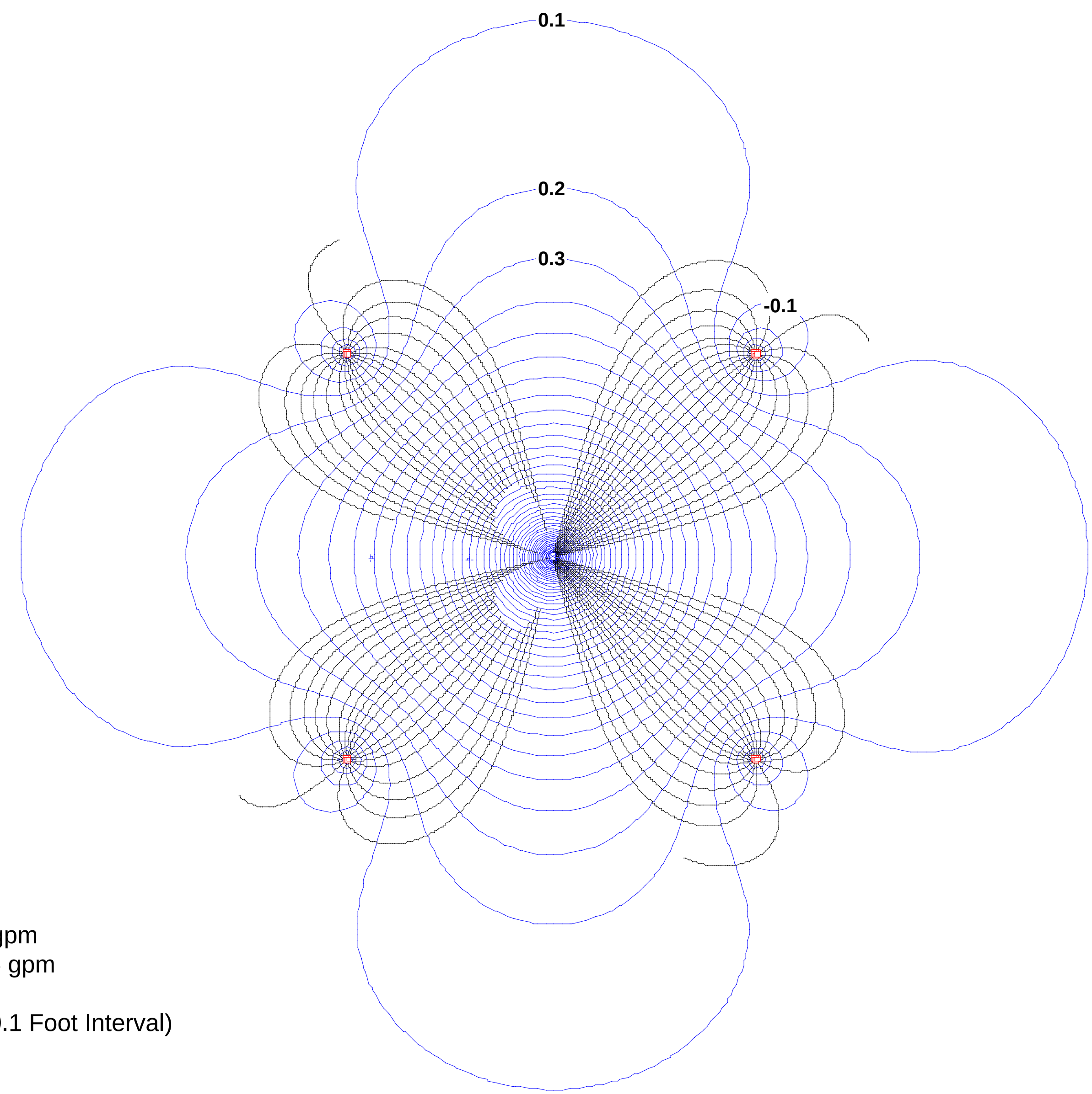

Layer 2 (Zone C)
Injection Rate = 1 gpm
Extraction Rate = 5 gpm
Time = 30 Days
Contours in Feet (0.1 Foot Interval)

FIGURE A.11
Preliminary Remediation System Model
Naval Training Center, Orlando, Florida
Study Area 17

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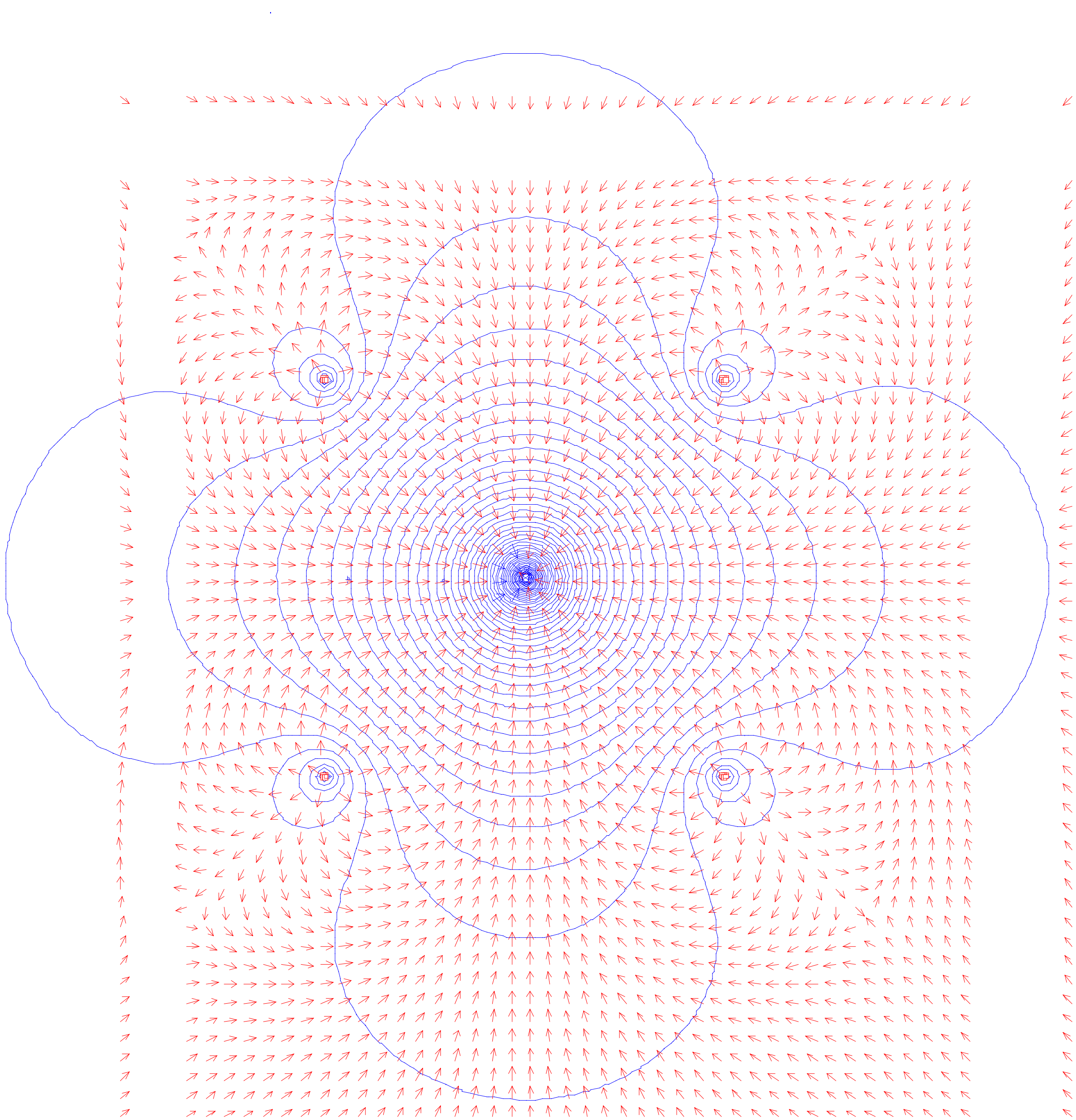

FIGURE A.12
Preliminary Remediation System Model
Naval Training Center, Orlando, Florida
Study Area 17

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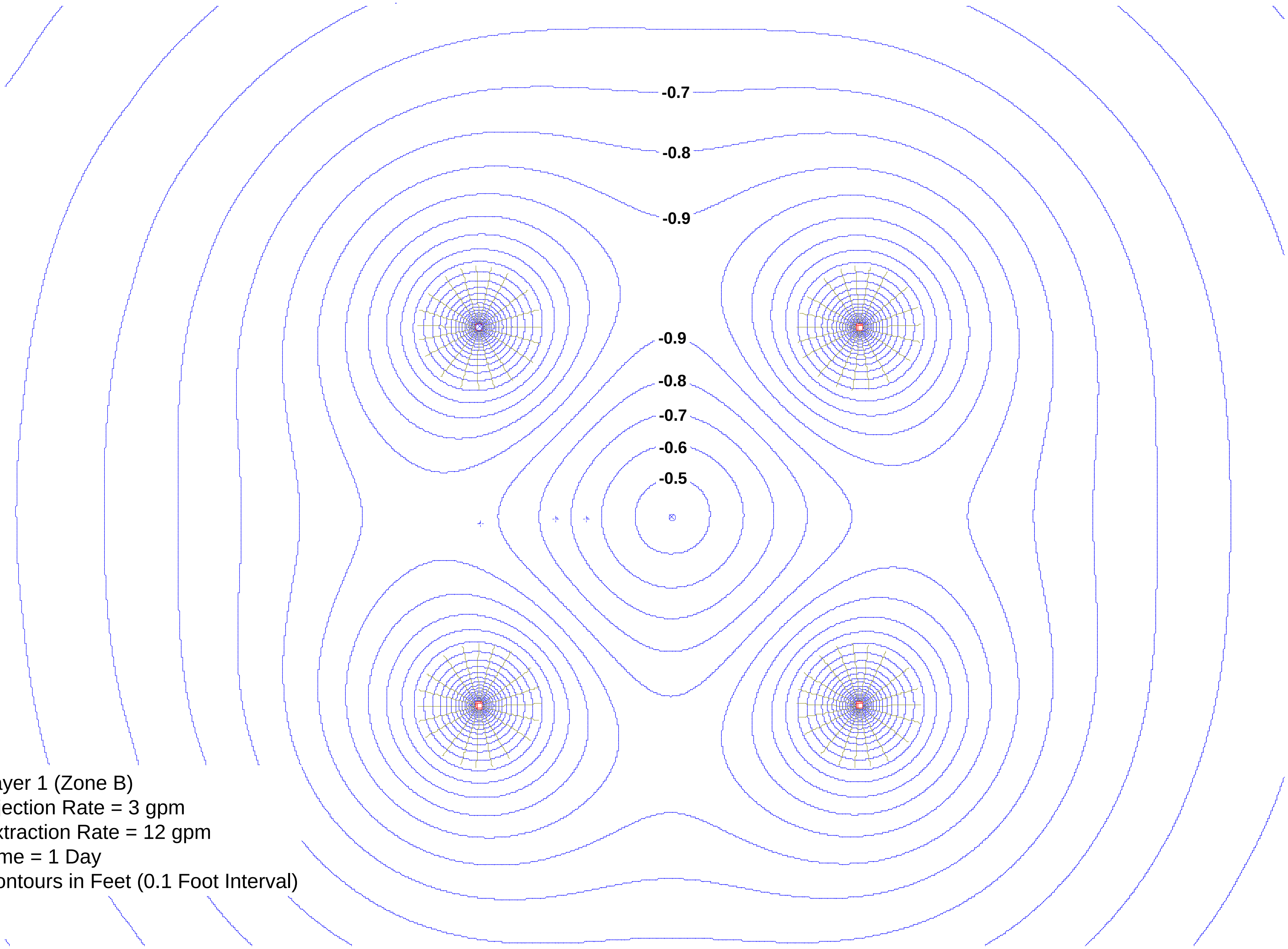
Attachment B

Particle Tracking Plots

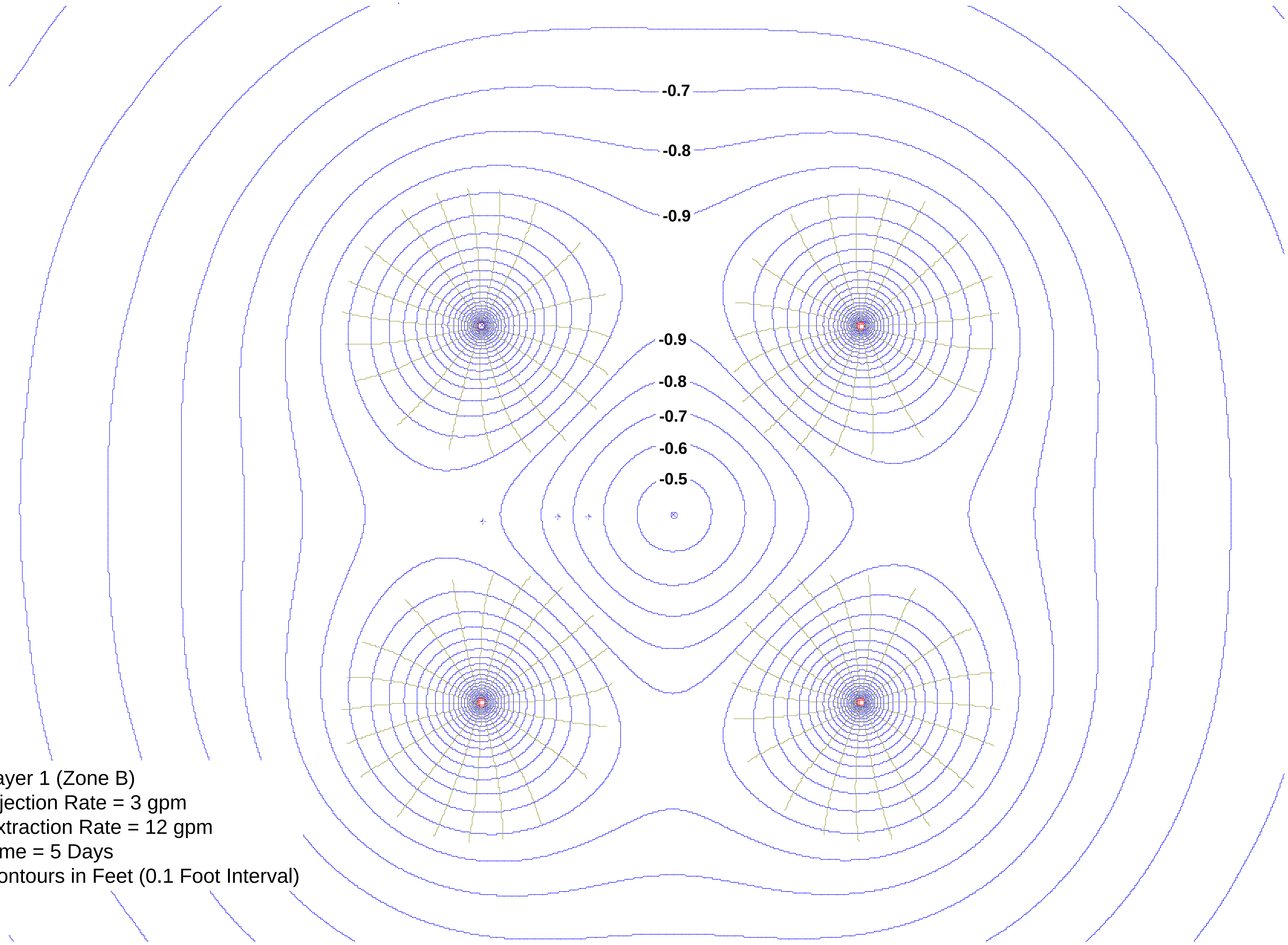
Injection Rate 3 gpm
Extraction Rate 12 gpm
per layer



Layer 1 (Zone B)
Injection Rate = 3 gpm
Extraction Rate = 12 gpm
Time = 1 Day
Contours in Feet (0.1 Foot Interval)

FIGURE B.1
Preliminary Remediation System Model
Naval Training Center, Orlando, Florida
Study Area 17

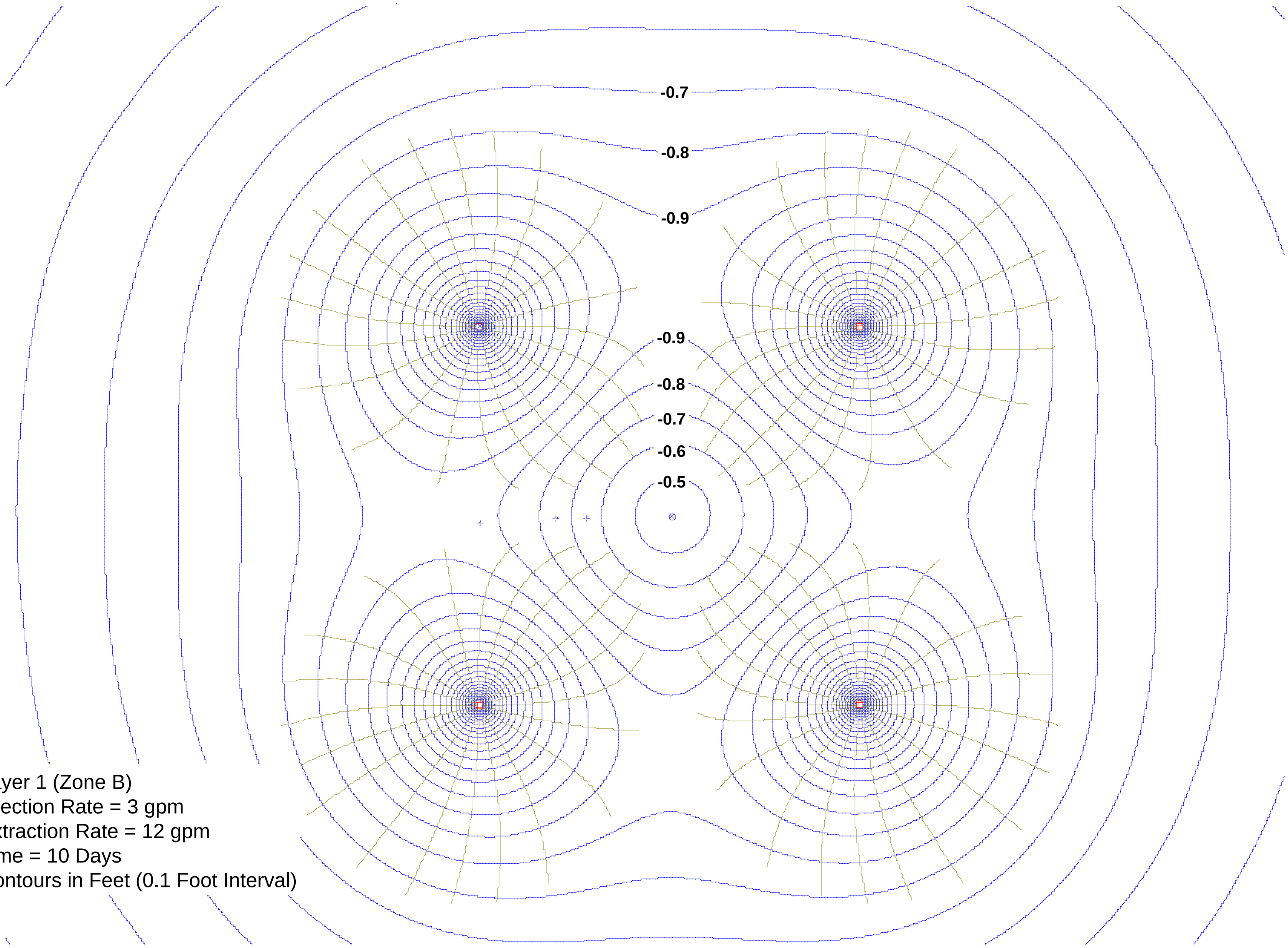
CH2MHILL



Layer 1 (Zone B)
Injection Rate = 3 gpm
Extraction Rate = 12 gpm
Time = 5 Days
Contours in Feet (0.1 Foot Interval)

FIGURE B.2
Preliminary Remediation System Model
Naval Training Center, Orlando, Florida
Study Area 17

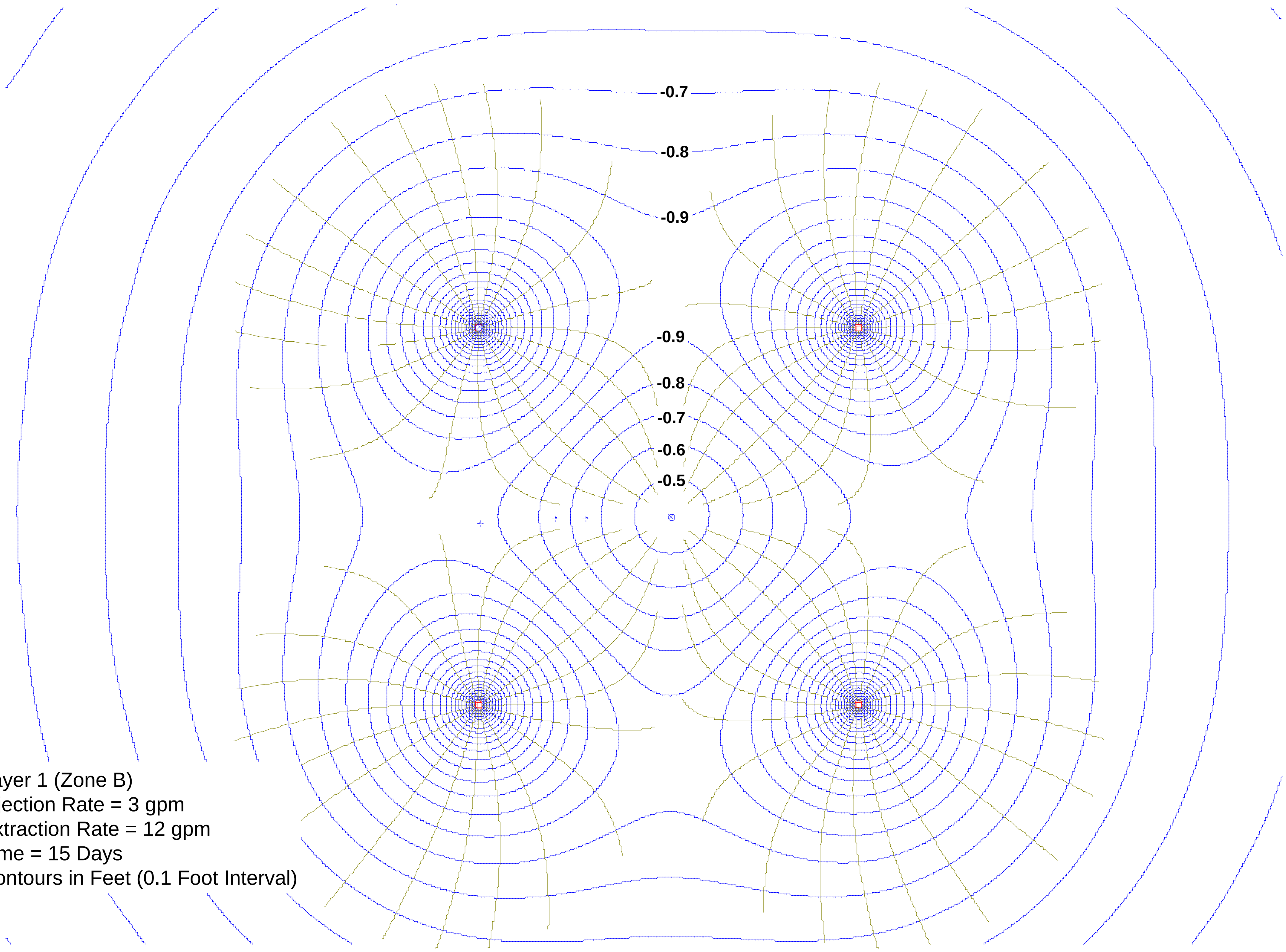
CH2MHILL



Layer 1 (Zone B)
Injection Rate = 3 gpm
Extraction Rate = 12 gpm
Time = 10 Days
Contours in Feet (0.1 Foot Interval)

FIGURE B.3
Preliminary Remediation System Model
Naval Training Center, Orlando, Florida
Study Area 17

CH2MHILL



Layer 1 (Zone B)
Injection Rate = 3 gpm
Extraction Rate = 12 gpm
Time = 15 Days
Contours in Feet (0.1 Foot Interval)

FIGURE B.4
Preliminary Remediation System Model
Naval Training Center, Orlando, Florida
Study Area 17

CH2MHILL

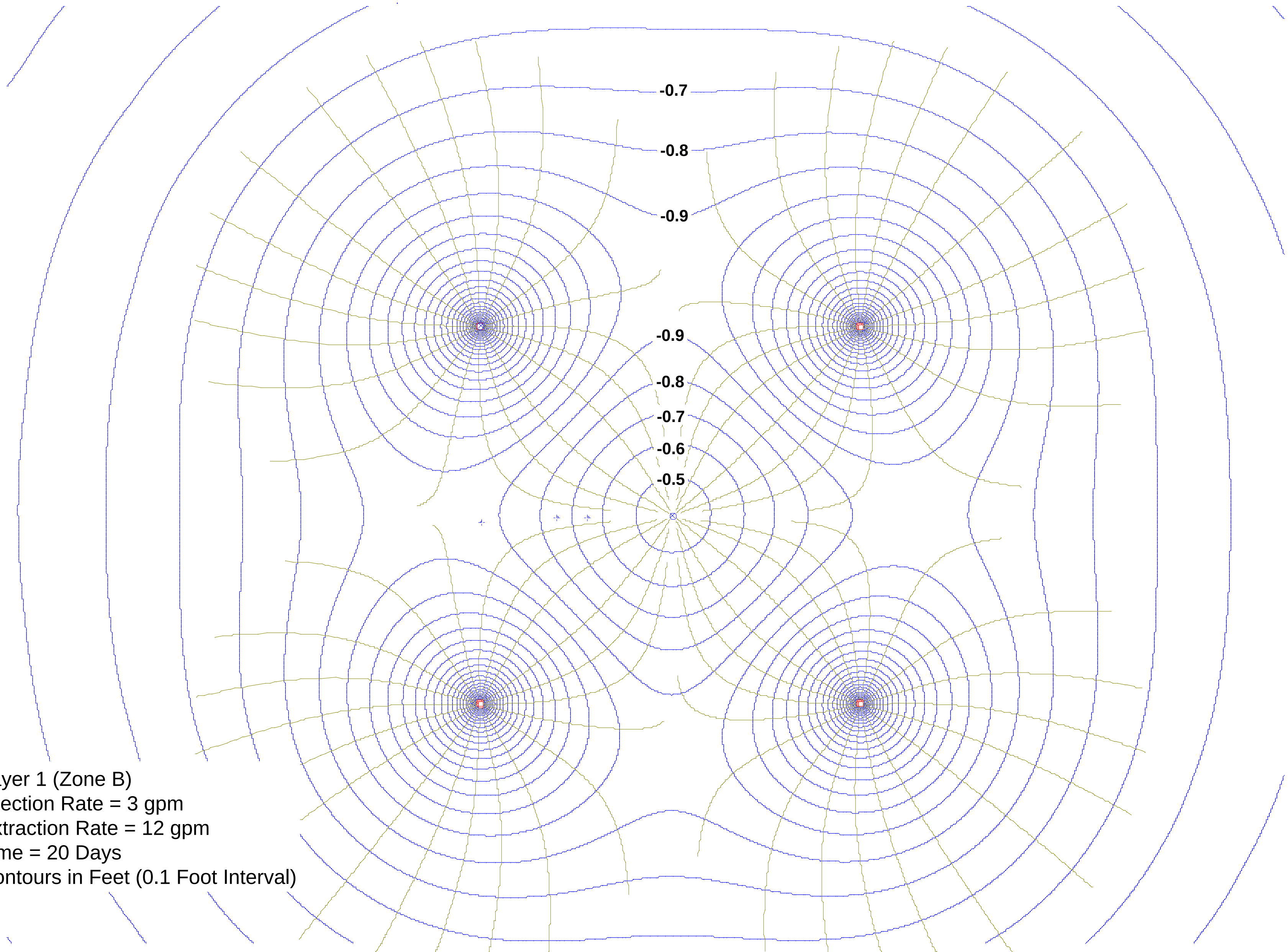
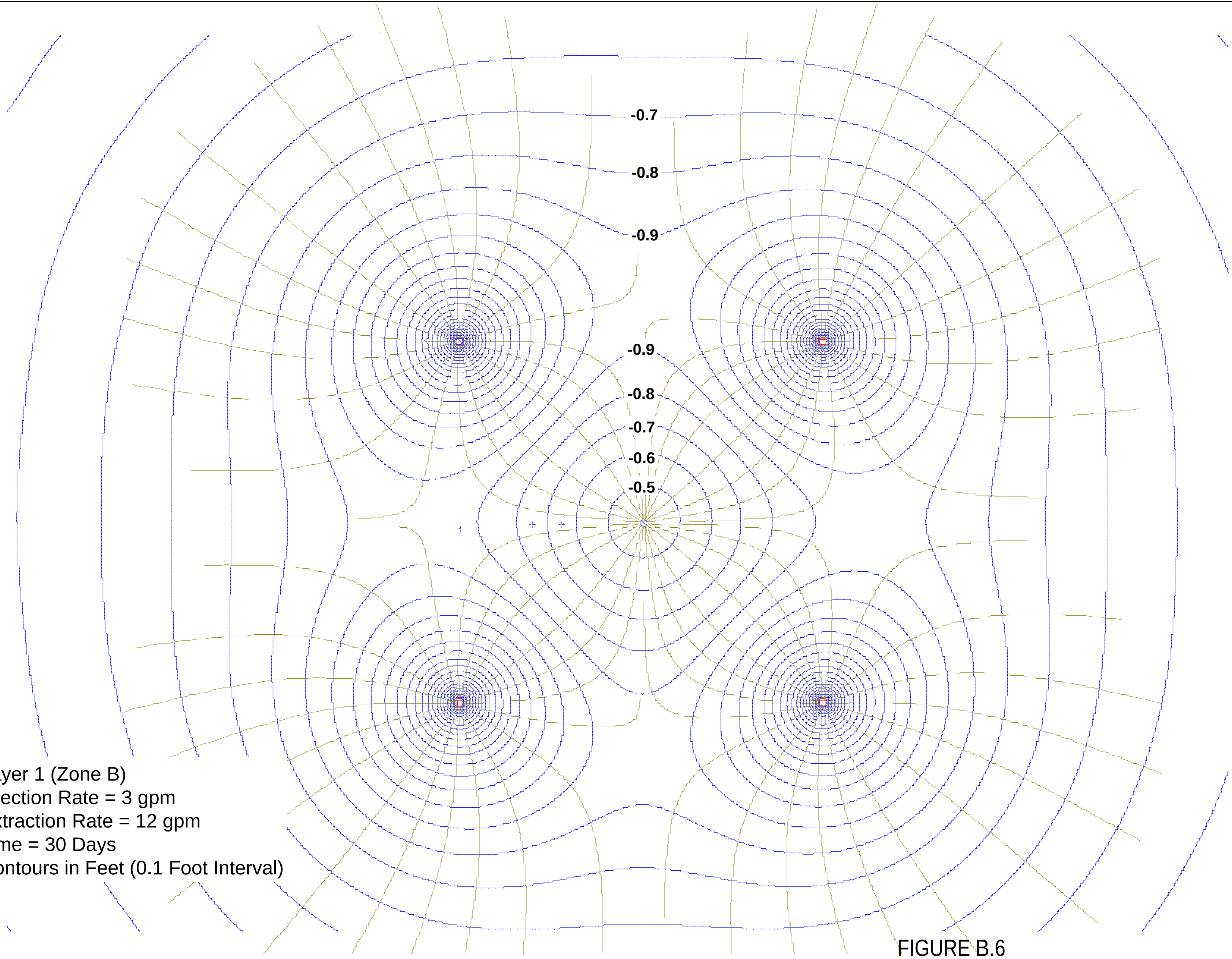


FIGURE B.5
Preliminary Remediation System Model
Naval Training Center, Orlando, Florida
Study Area 17

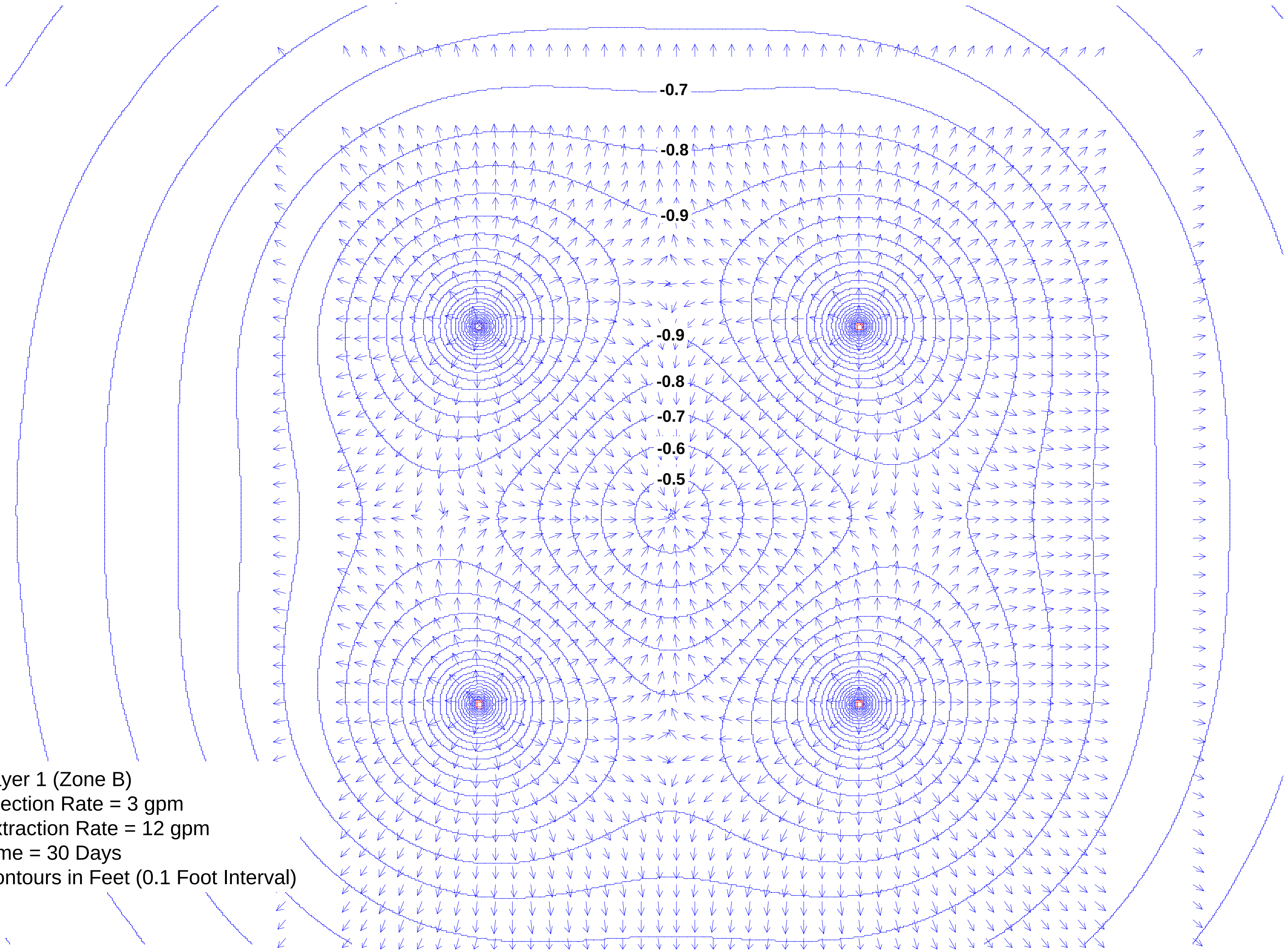
CH2MHILL



Layer 1 (Zone B)
Injection Rate = 3 gpm
Extraction Rate = 12 gpm
Time = 30 Days
Contours in Feet (0.1 Foot Interval)

FIGURE B.6
Preliminary Remediation System Model
Naval Training Center, Orlando, Florida
Study Area 17

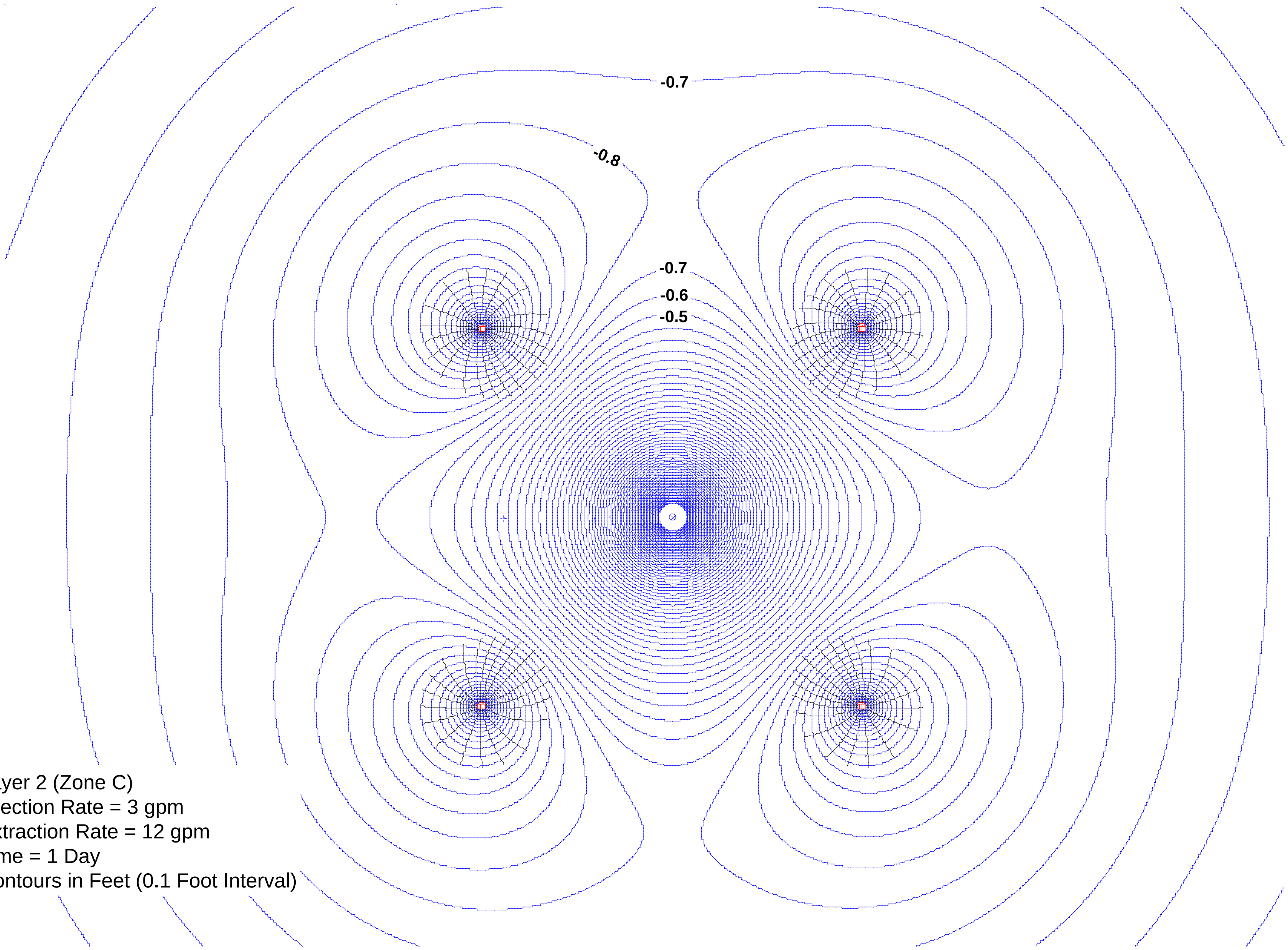
CH2MHILL



Layer 1 (Zone B)
Injection Rate = 3 gpm
Extraction Rate = 12 gpm
Time = 30 Days
Contours in Feet (0.1 Foot Interval)

FIGURE B.7
Preliminary Remediation System Model
Naval Training Center, Orlando, Florida
Study Area 17

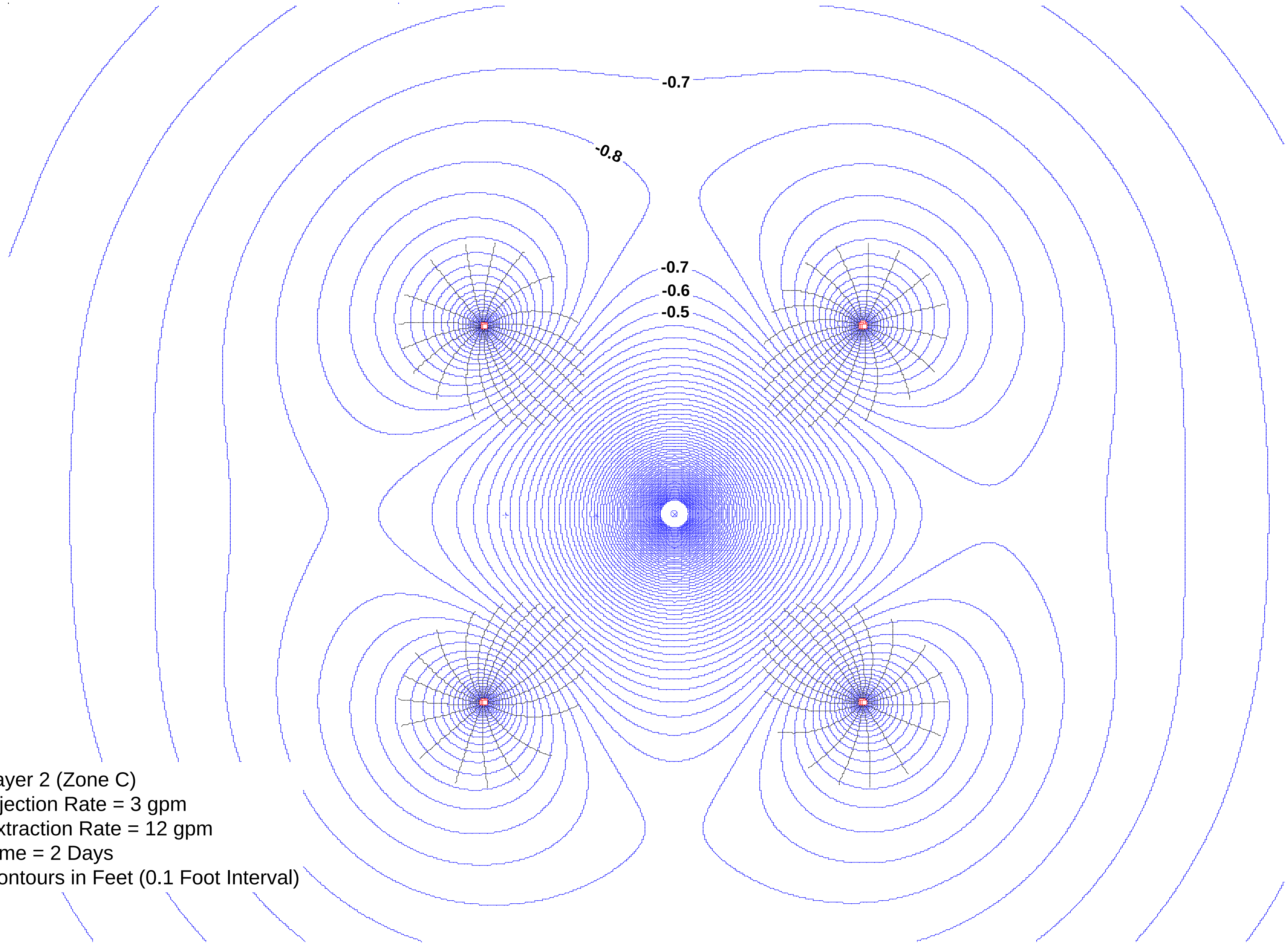
CH2MHILL



Layer 2 (Zone C)
Injection Rate = 3 gpm
Extraction Rate = 12 gpm
Time = 1 Day
Contours in Feet (0.1 Foot Interval)

FIGURE B.8
Preliminary Remediation System Model
Naval Training Center, Orlando, Florida
Study Area 17

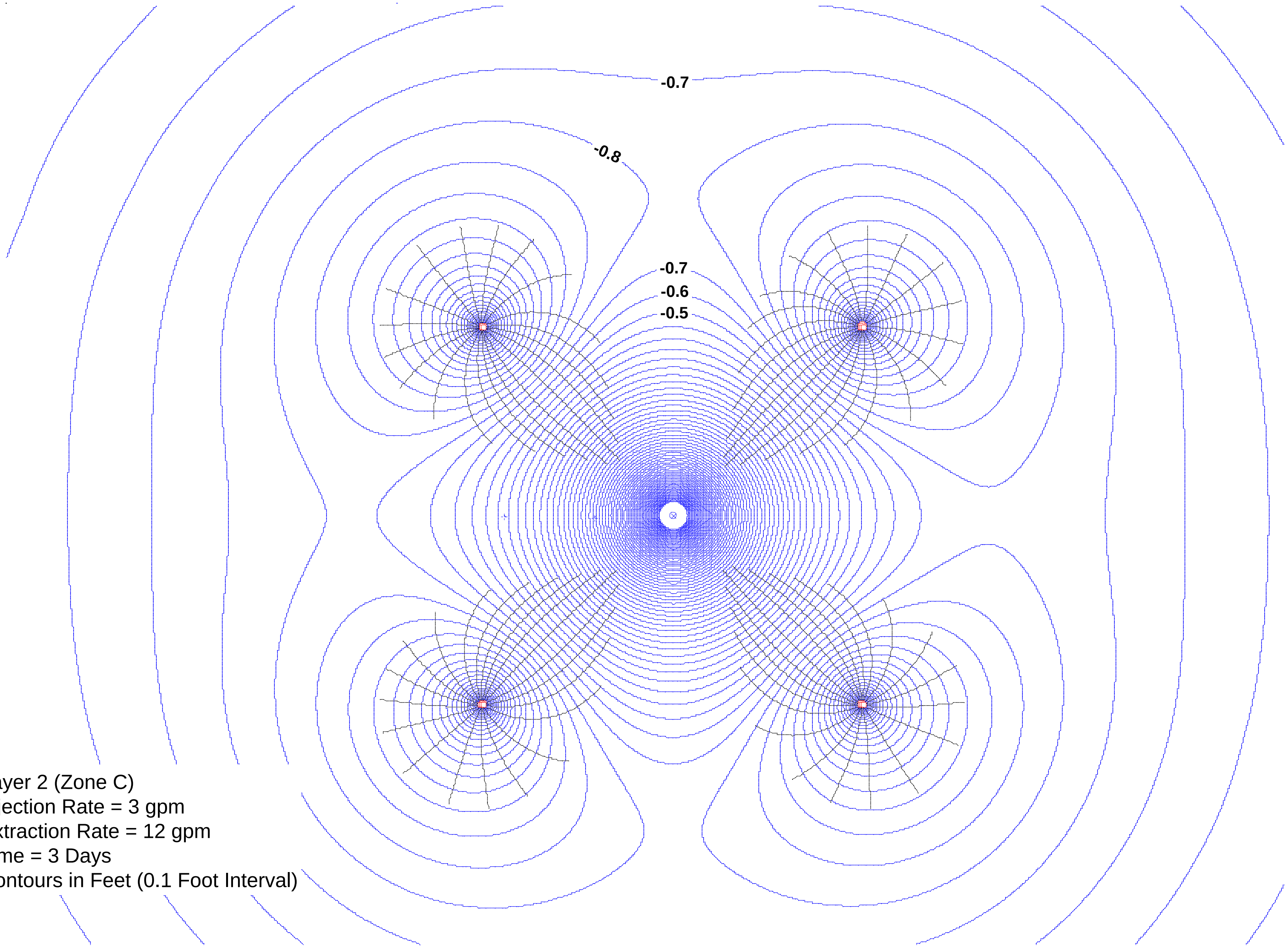
CH2MHILL



Layer 2 (Zone C)
Injection Rate = 3 gpm
Extraction Rate = 12 gpm
Time = 2 Days
Contours in Feet (0.1 Foot Interval)

FIGURE B.9
Preliminary Remediation System Model
Naval Training Center, Orlando, Florida
Study Area 17

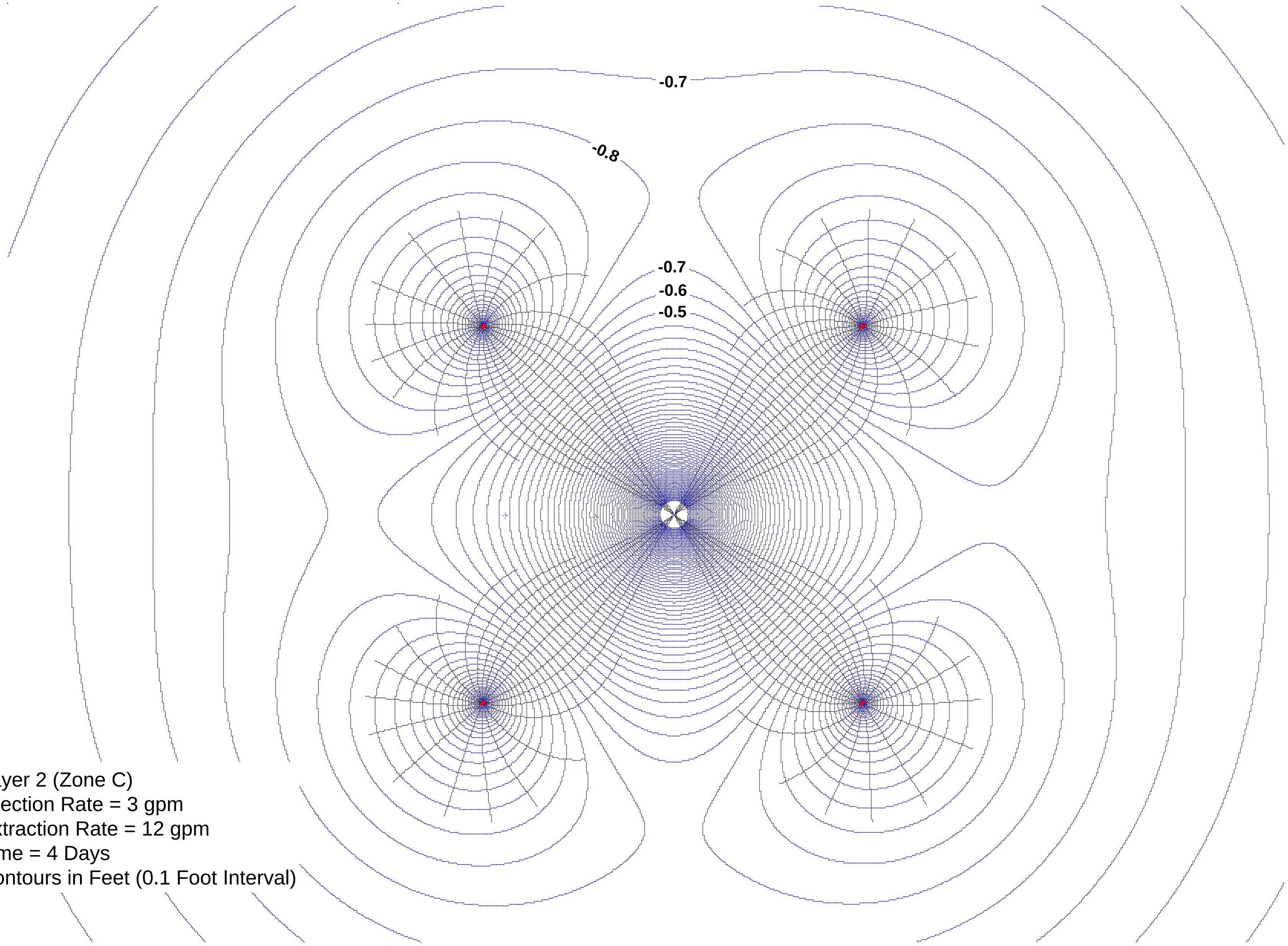
CH2MHILL



Layer 2 (Zone C)
Injection Rate = 3 gpm
Extraction Rate = 12 gpm
Time = 3 Days
Contours in Feet (0.1 Foot Interval)

FIGURE B.10
Preliminary Remediation System Model
Naval Training Center, Orlando, Florida
Study Area 17

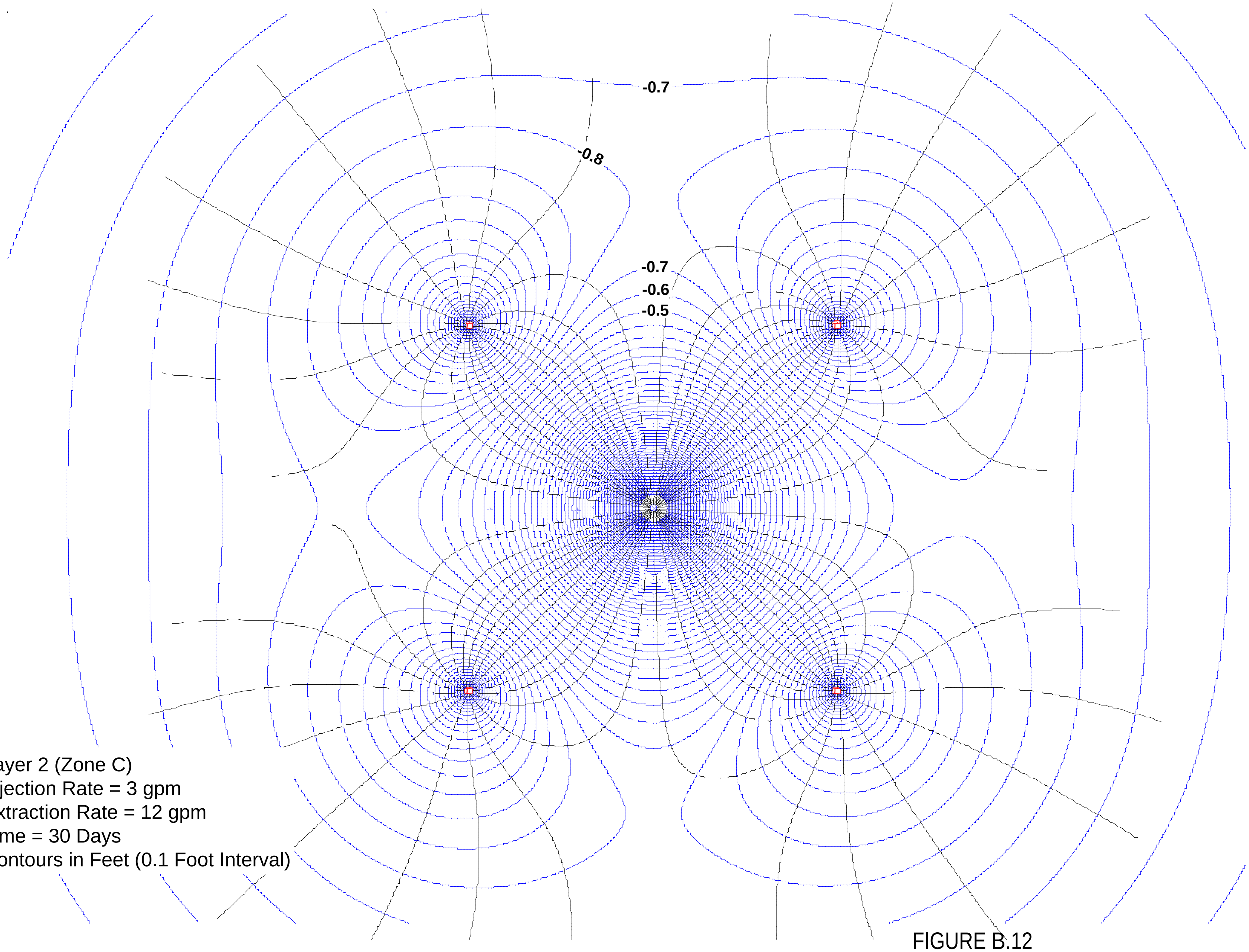
CH2MHILL



Layer 2 (Zone C)
Injection Rate = 3 gpm
Extraction Rate = 12 gpm
Time = 4 Days
Contours in Feet (0.1 Foot Interval)

FIGURE B.11
Preliminary Remediation System Model
Naval Training Center, Orlando, Florida
Study Area 17

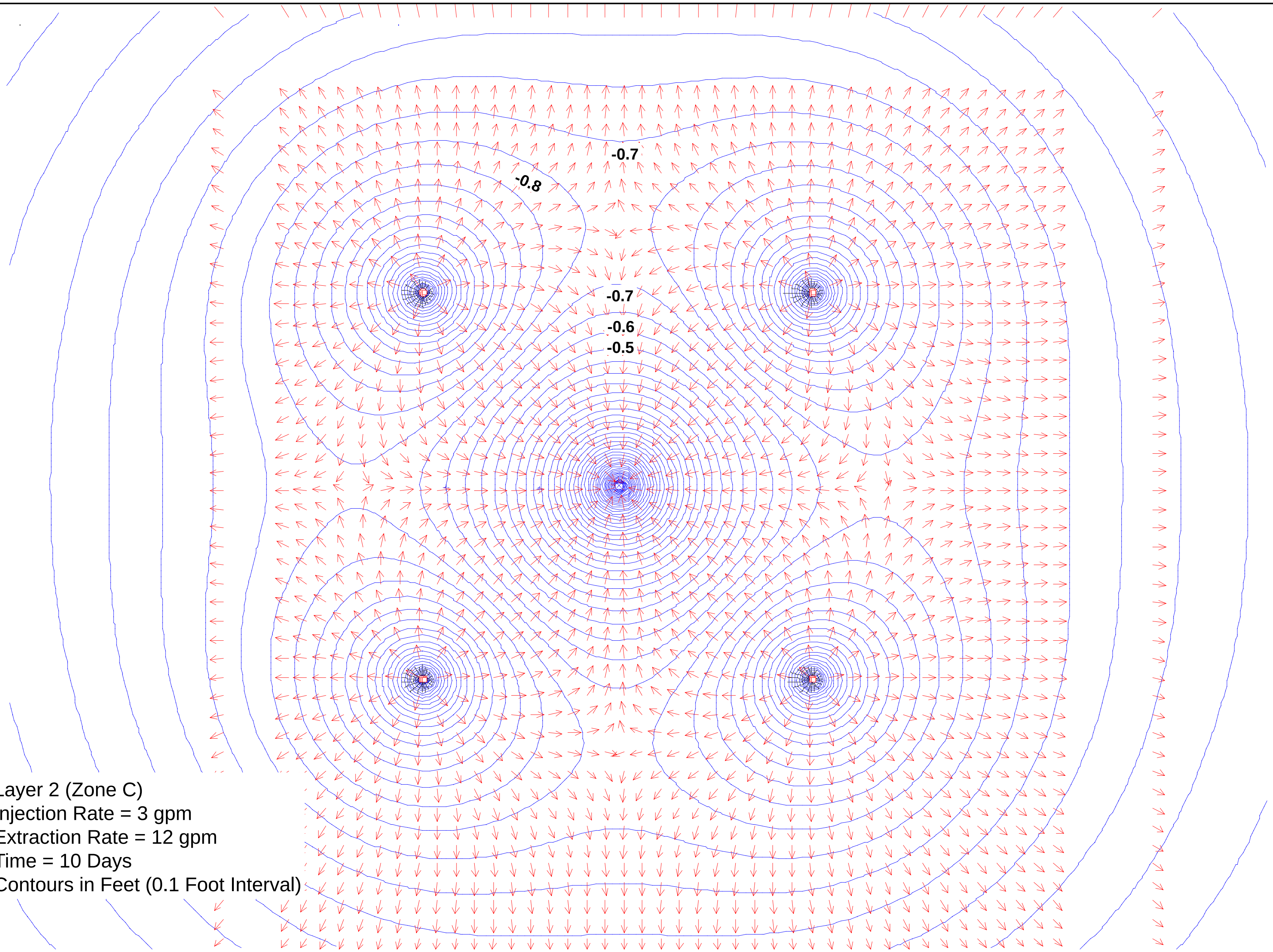
CH2MHILL



Layer 2 (Zone C)
Injection Rate = 3 gpm
Extraction Rate = 12 gpm
Time = 30 Days
Contours in Feet (0.1 Foot Interval)

FIGURE B.12
Preliminary Remediation System Model
Naval Training Center, Orlando, Florida
Study Area 17

CH2MHILL



Layer 2 (Zone C)
Injection Rate = 3 gpm
Extraction Rate = 12 gpm
Time = 10 Days
Contours in Feet (0.1 Foot Interval)

FIGURE B.13
Preliminary Remediation System Model
Naval Training Center, Orlando, Florida
Study Area 17

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Addendum 2 - Orlando Naval Training Center Study Area 17 (SA-17) Preliminary Remediation System Modeling Summary

PREPARED FOR: CH2M HILL/ATL

PREPARED BY: CH2M HILL/TPA, CH2M HILL GNV

COPIES:

DATE: January 26, 2006

This technical memorandum addendum summarizes additional groundwater modeling conducted for the Orlando, Florida Navy Training Center Study Area 17 (SA-17). The previous version of the model described in Addendum 1 (October 5, 2005) was modified to account for the higher viscosity of the emulsified oil substrate, compared to fresh water.

Tables and Figures are located at the end of the report in the order they are referenced. Attachments follow the Tables and Figures.

Background

The Navy Training Center SA-17 is located west of the Orland International Airport. The location of the site is shown in Figure 1. The CVOC contamination at SA-17 is within the surficial aquifer. The site will be remediated by injecting emulsified oil substrate around the outer perimeter of contamination plume while pumping from a recovery well located in the center of the plume to maintain a gradient towards the contamination area. The purpose of this effort was to account for the higher viscosity of the emulsified oil substrate relative to fresh water in the design of the remediation system.

The surficial aquifer at SA-17 exists to approximately 50 feet bls and consists primarily of sand with intermittent layers of low porosity silty sand. The sub-surface has been delineated into different zones based on semiconfinment layers that exist within the aquifer. For the purpose of this model simulation, the aquifer is divided into two layers. The first (top) layer represents zones A and B. Layer 2 represents zone C. The bottom of layer 2 is assumed to be impermeable. Layer 1 extends from 0 to 25 feet and layer 2 from 25 to 50 feet bls. The water table is assumed to be at 0 feet. A thin layer of semi-confining silty sand separates Zone C from Zones A and B.

A constant rate pumping test was conducted at OLD Well 17 –MW 51C on August 16, 2005. The pumped well is a 2-inch diameter well screened from 42 to 47 feet bls (Zone C). Eight new 1-inch diameter PVC peizometers were constructed prior to the pump test to be used as monitoring wells (PZ-01S, PZ02S, PZ-03S, PZ-04S, PZ-01D, PZ-02D, PZ-03D, and PZ-04D). The peizometers designated with an “S” (shallow) are complete with a screen interval from

20-21 feet bls (Zone B). The "D" (deep) wells are completed with screened intervals from 35-36 feet bls (Zone C).

The data was analyzed and the following average aquifer parameters were estimated:

- Transmissivity of 1,050 gpd/ft (140 ft2/d) (Zone C)
- Storativity of 0.016
- Hydraulic Conductivity of 5.6 ft/d (Zone C)

Adjustment to Observed Hydraulic Conductivity Due to the Emulsified Oil Substrate (EOS)

The hydraulic conductivity (K) may be defined (Freeze and Cherry, 1972) as:

$$K = k\frac{\rho g}{\mu} \tag{1}$$

where:

K = hydraulic conductivity

k = intrinsic permeability of the matrix

μ = dynamic viscosity of the fluid

ρ = density of the fluid

g = acceleration due to gravity

If the dynamic viscosity (μ) is written in terms of the kinematic viscosity (ν),

$$\mu = \nu\rho \tag{2}$$

then one can define the hydraulic conductivity in terms of the intrinsic permeability (k), kinematic viscosity (μ), and the acceleration due to gravity (g):

$$K = k\frac{g}{\nu} \quad (3).$$

The average hydraulic conductivity at the site is 5.6 ft/d (1.97×10^{-5} m/s) and the kinematic viscosity of water at 20°C is 1.0×10^{-6} m^2/s, therefore the intrinsic permeability (k) is:

$$k = K\frac{\nu}{g} = 1.97 \times 10^{-5}\, m/s \frac{1 \times 10^{-6}\, m^2/s}{9.8 m/s^2} = 2.0 \times 10^{-12}\, m^2 \tag{4}$$

Knowing the intrinsic permeability *k*, the hydraulic conductivity *K* can then be calculated for any kinematic viscosity (ν) with Equation 3.

Table 1 presents laboratory-measured kinematic viscosities for various emulsions of oil by weight, ranging from 1% to 20%, and the resultant hydraulic conductivity for the SA-17 site.

TABLE 1
KINEMATIC VISCOSITY AND ADJUSTED SA-17 HYDRAULIC CONDUCTIVITY FOR VARIOUS OIL EMULSION CONCENTRATIONS

Oil concentration (%) by weight	Ratio of kinematic viscosity of emulsion to water	Adjusted hydraulic conductivity (ft/d), including ±20% error
1	1.20	3.84 – 5.76
3	1.30	3.55 – 5.32
5	1.50	3.07 – 4.61
10	1.75	2.63 – 3.95
20	3.0	1.54 – 2.31

A K value of 2.63 ft/day was selected from Table 1 as a conservative value for groundwater modeling, and is based on the site average hydraulic conductivity (5.6 ft/day) adjusted downward for the EOS viscosity effects at an EOS solution of 10% in water.

This K value is also adjusted down by a factor of 1.2 to account for the range of error of the EOS kinematic viscosity data provided to CH2M HILL by Solutions, Inc. The 10% EOS solution is representative of the highest EOS concentrations likely to be injected at SA-17, and is therefore also a conservative assumption.

Groundwater Modeling

Simulation 3 –Injection Wells at 0.5 and 1 gpm, Extraction Wells at 3 and 6 gpm

This MODFLOW model run was conducted to simulate the injection of the emulsified oil substrate into 6 perimeter injection wells located approximately 25 feet from the extraction well, which is located in the middle of these wells. Each model layer has an identical remediation configuration except with different well depths to target Zone A/B or C. The model simulation assumes continuous operation of the injection and extraction wells.

The hydraulic conductivity of both layers of the groundwater flow model was reduced from 5.6 ft/d to 2.63 ft/d, based on the increased viscosity of the EOS solution in water, as described above. This simulation incorporated a total injection rate of 9 gpm split between 6 injection wells in Layer 1 injecting at 0.5 gpm each (for a total injection rate of 3 gpm) and 6 injection wells injecting at 1 gpm each in Layer 2 (for a total injection rate of 6 gpm). The extraction well in Layer 1 pumped at 3 gpm, the extraction well in Layer 2 pumped at 6 gpm.

The extraction and injection rates in model layer 1 were reduced because the lower hydraulic conductivity resulted in the model simulating the water table dropping below the bottom of layer 1 near the extraction well at a 6 gpm pumping rate.

Groundwater drawdown/mounding contours are presented in the attachments. Figure 1 depicts the simulated change in water levels in the injection wells, Figure 2 depicts the simulated change in water levels in the extraction wells. Table 2 summarizes the simulation results.

Table 2
MODFLOW Simulation Summary
US Navy SA-17 Revised Remediation Modeling Summary

Simulation	Injection Well mounding (feet)	Extraction Well Drawdown (feet)	Comments
Layer 1			
Inject 0.5 gpm in 6 wells Withdrawal 3 gpm in 1 well	0.61 – 1.05 feet	9.23 feet	Reached extraction well in 6 days
Layer 2			
Inject 1 gpm in 6 wells Withdrawal 6 gpm in 1 well	1.56 – 2.21 feet	16.62 feet	Reached extraction well in 4 days

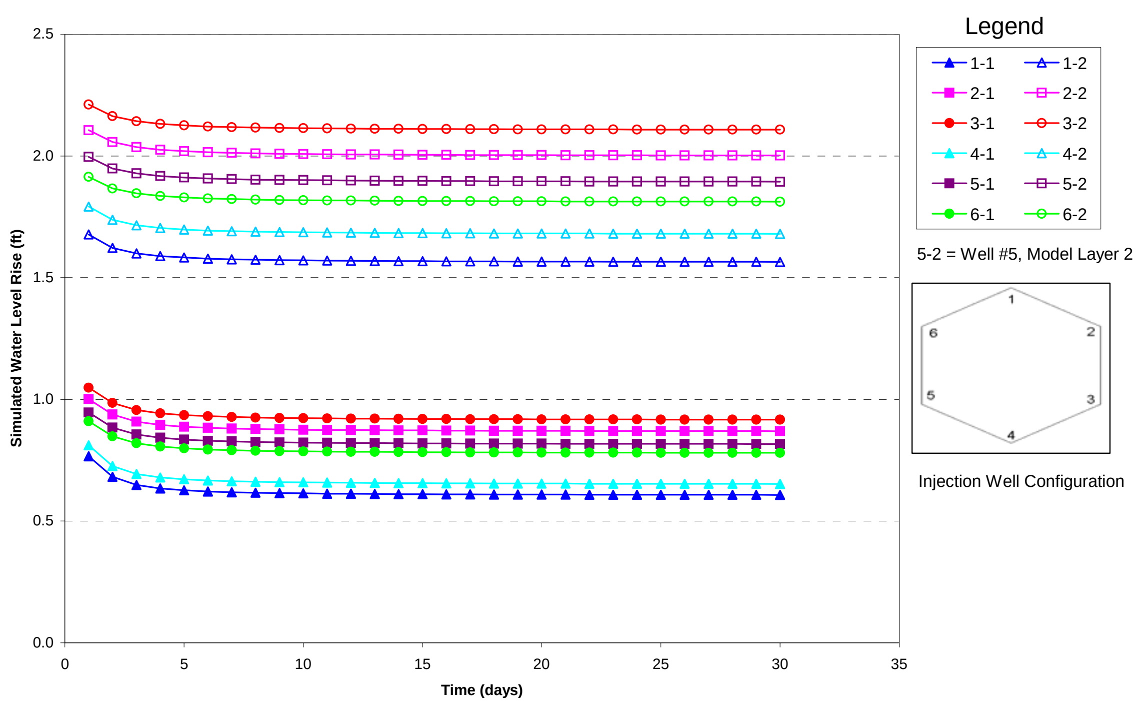


FIGURE 1
SIMULATED CHANGE IN WATER LEVEL IN INJECTION WELLS

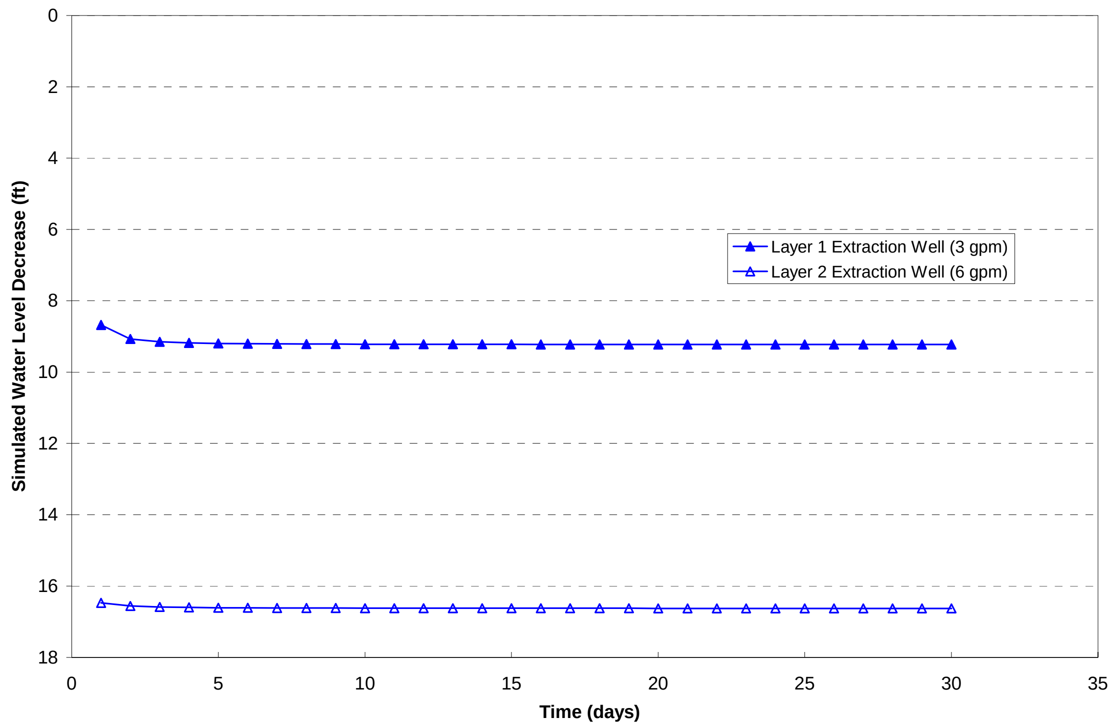


FIGURE 2
SIMULATED CHANGE IN WATER LEVEL IN EXTRACTION WELLS

Stream Line and Particle Tracking Assessment

The simulation used the particle tracking method to show the bulk ground water flow direction each particle would take to reach the extraction well. The simulation plots show the groundwater contours for the operating system (in 0.1-foot increments). In these simulations, 20 particles were released in the cell of each injection well. The plots show the path lines taken for each particle based on the calculated groundwater flow velocity and the groundwater gradient.

The results show the travel time for the substrate from the injection wells to the extraction well is between 4 days (96 hours) and 6 days (144 hours).

Reviewing the 10-day and 30-day operation particle trace plots of both layers for this simulation shows that the substrate has generally been uniformly distributed throughout the aquifer. The aquifer area between the injection wells which may not be impacted by the injected substrate has been greatly reduced if not eliminated. With total injectate of 9 gpm (both layers), the hydraulic gradient from the extraction well remains adequate to capture all injected substrate towards the direction of the extraction well. The groundwater velocity vector plots for each layer provide the extent of the impact the extraction well has on the injected substrate.

Summary and Conclusions

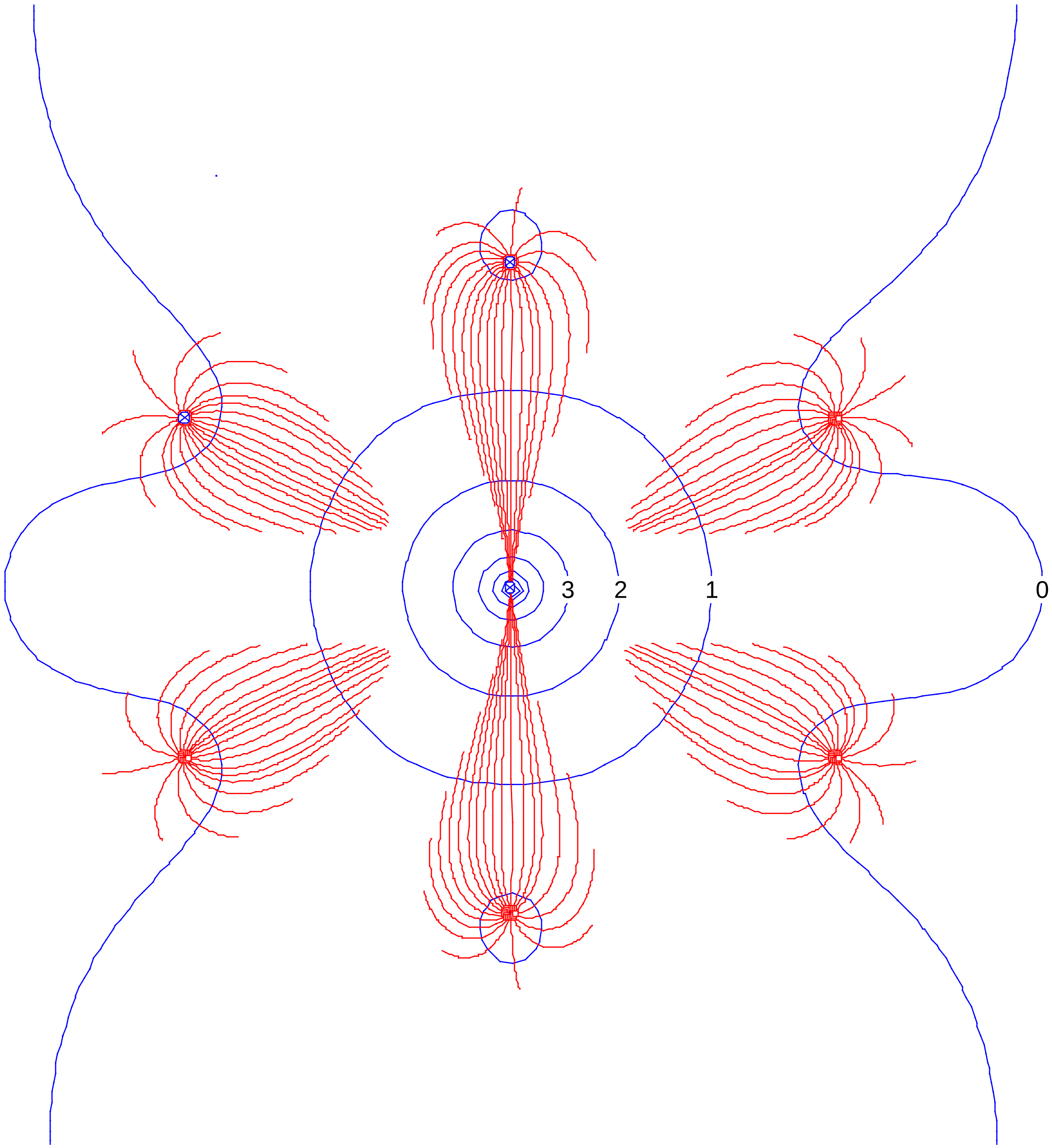
By reducing the hydraulic conductivity, the Layer 1 extraction well will not support 6 gpm. Therefore, for this simulation the extraction rate in Layer 1 was reduced to 3 gpm. The field operation of this system will need to be adjusted between 3 and 6 gpm in order to find a flow rate that will be sustainable for the duration of the EOS injection.

With a total extraction rate of 9 gpm, the hydraulic gradient from the extraction wells remains adequate to capture all injected substrate towards the direction of the extraction wells. The Zone B aquifer (Layer 2) is able to support an extraction rate of 6 gpm without going dry, but potentially with an increased drawdown due to the EOS® viscosity affects on hydraulic conductivity.

Attachment C

Particle Tracking Plots

Layer 1: Injection Rate 0.5 gpm per well, Extraction Rate 3 gpm
Layer 2: Injection Rate 1 gpm per well, Extraction Rate 6 gpm



Layer 1 (Zone B)
Injection Rate = 0.5 gpm
Extraction Rate = 3 gpm
Time = 6 Days
Contours Interval = 1 Foot

FIGURE A.1
Preliminary Remediation System Model
Naval Training Center, Orlando, Florida
Study Area 17

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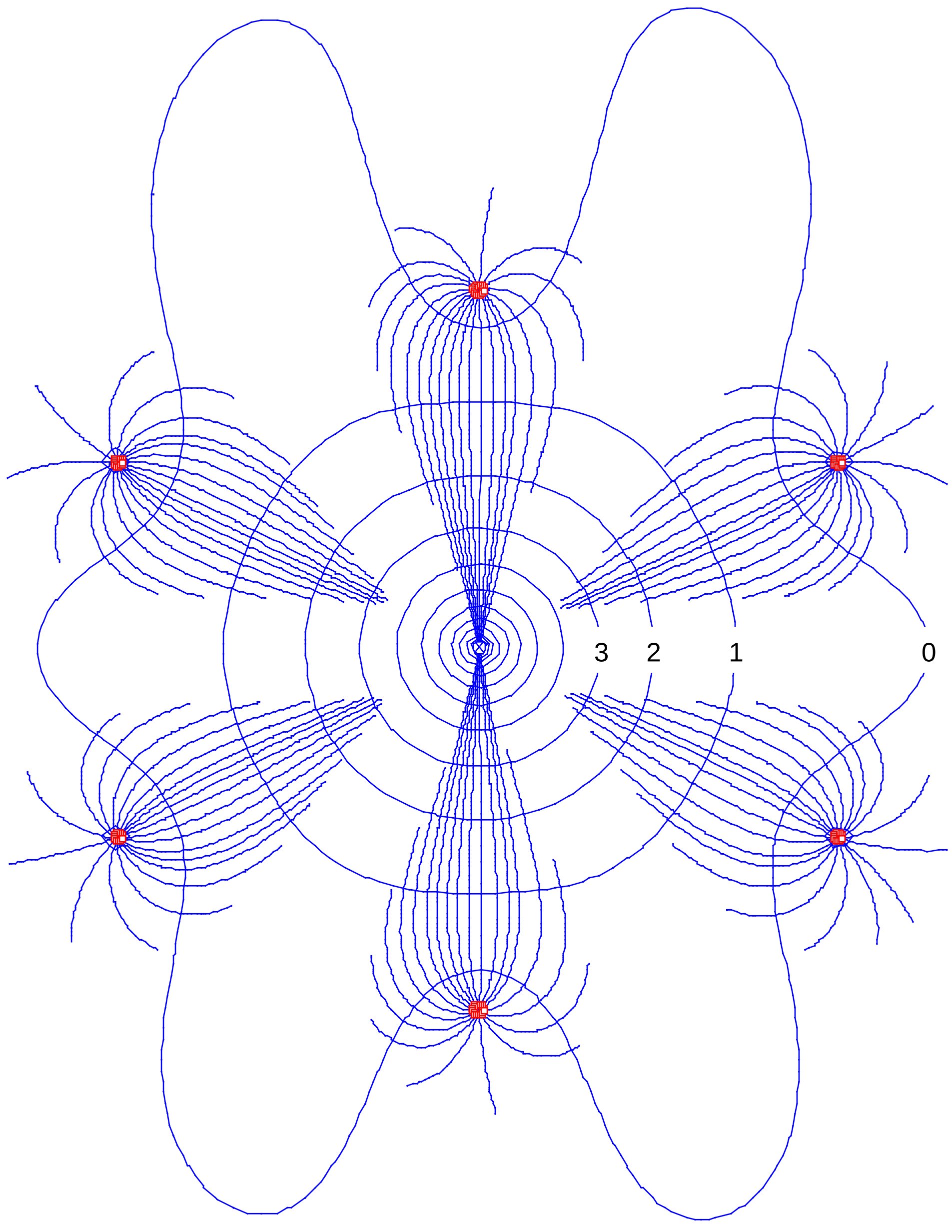

Layer 2 (Zone C)
Injection Rate = 1 gpm
Extraction Rate = 6 gpm
Time = 4 Days
Contours Interval = 1 Foot

FIGURE A.2
Preliminary Remediation System Model
Naval Training Center, Orlando, Florida
Study Area 17

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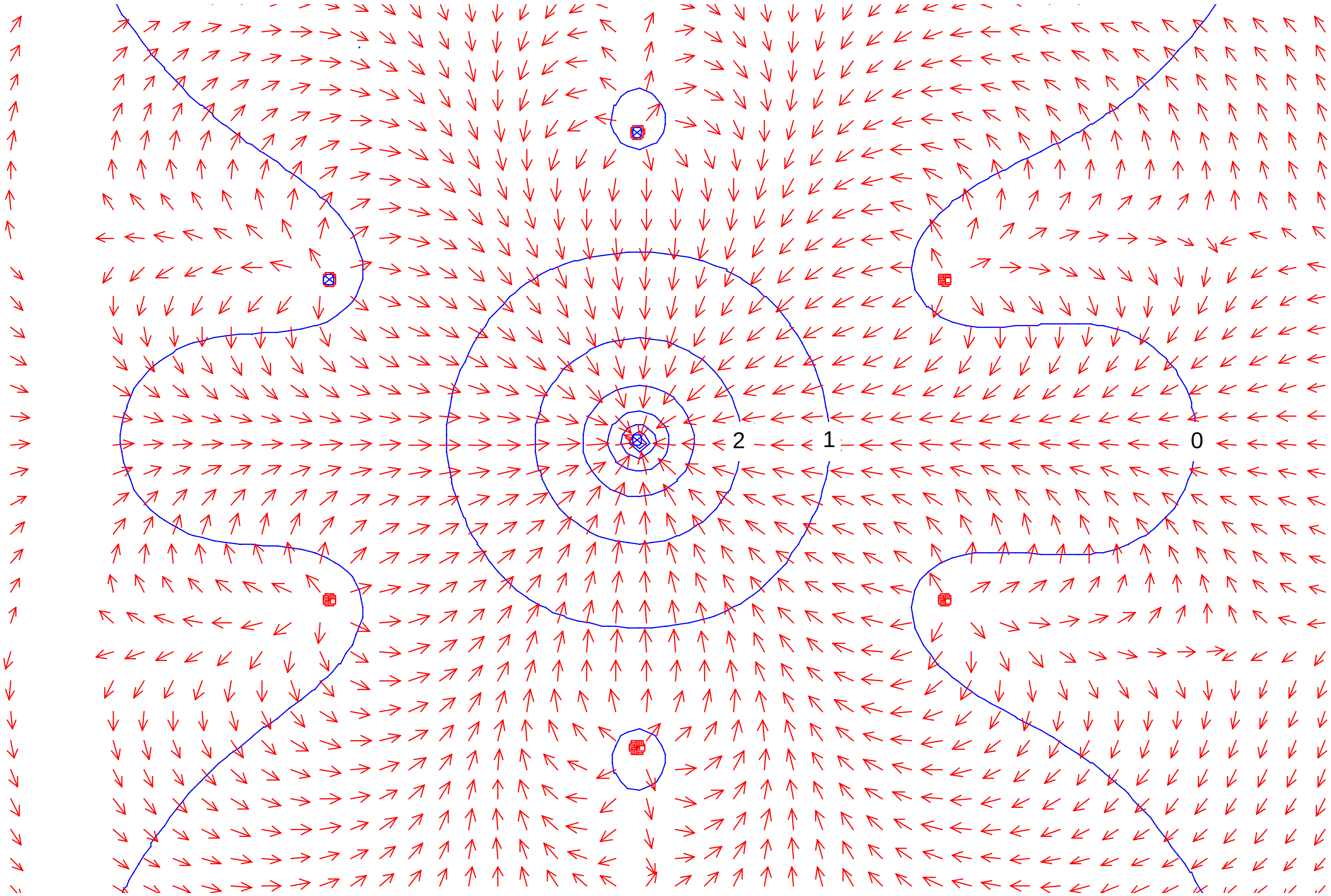
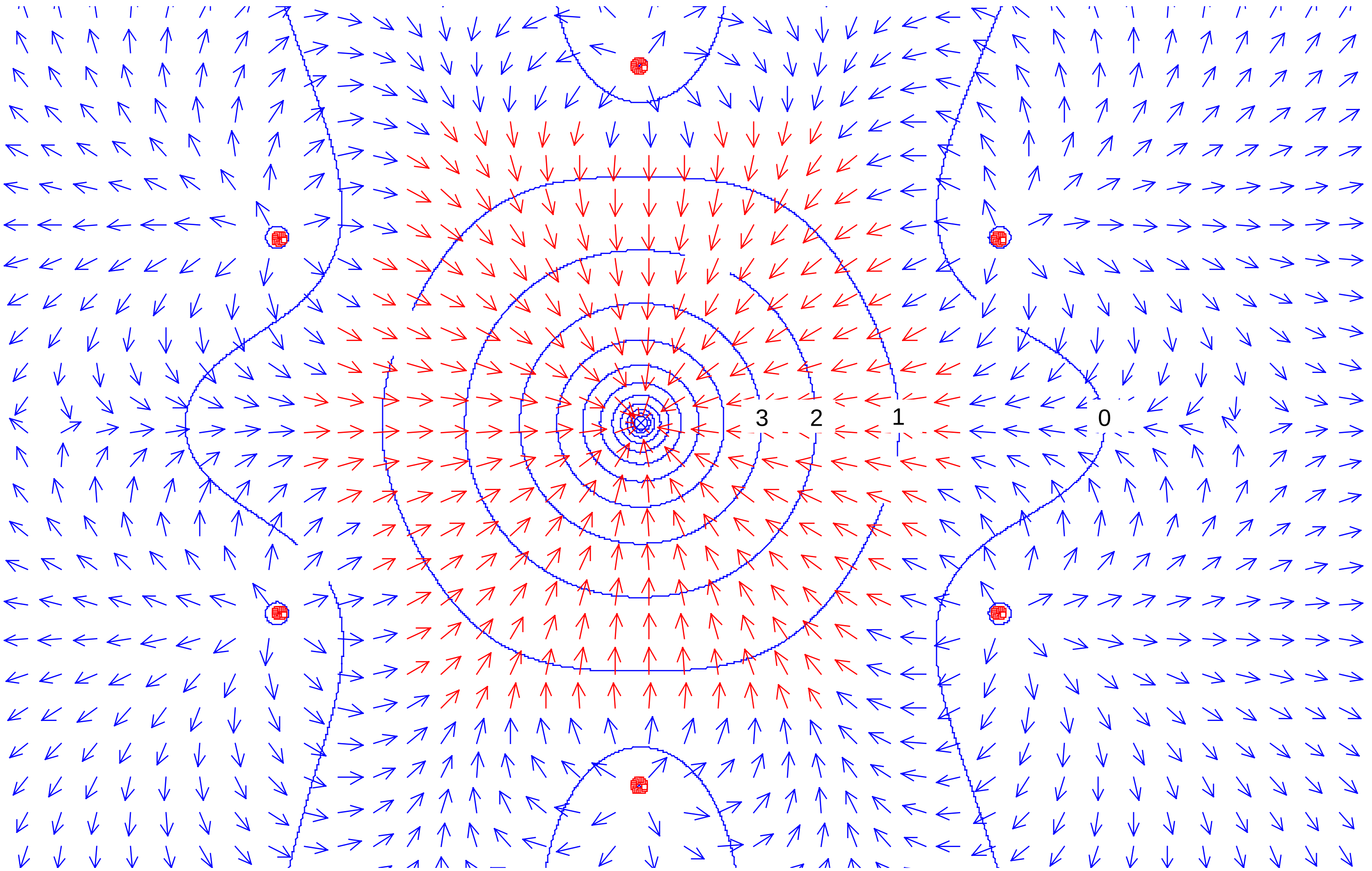


Groundwater Flow Field at 30 Days (Zone B)

FIGURE A.3
Preliminary Remediation System Model
Naval Training Center, Orlando, Florida
Study Area 17

CH2MHILL



Groundwater Flow Field at 30 Days (Zone C)

FIGURE A.4
Preliminary Remediation System Model
Naval Training Center, Orlando, Florida
Study Area 17

		Percent Passing									
Boring Number	Sample Depth	No. 10 2.000	No. 40 0.425	No. 60 0.250	No. 100 0.150	No. 200 0.075	Moisture Content	Specific Gravity	LL	PI	USCS
MIP37	30-34	100	98.7	77.3	7.7	0.1	30.2				
MIP37	20-24	100	93.4	64.6	29.1	0.3	38.6				
MIP37	36-40	100	99.2	85.3	15.1	3.8	24.6				
MIP35	20-24	100	92.7	61.5	29.3	10.5	23.2				
MIP09	20-24	99.9	94.4	78.8	39.9	5.6	24.4				
MIP06	20-24	100	94	65.9	34.5	7.9	25.9				
MIP06	16-20	100	97.5	87.5	63.9	0.5	42.7				
MIP10	24-28	100	98.1	89.1	71	0.7	47.5				
MIP36	24-28	100	96.9	83.5	65.5	13.5	25.2				

		Percent Retained									
Boring Number	Sample Depth	No. 10 2.000	No. 40 0.425	No. 60 0.250	No. 100 0.150	No. 200 0.075	Moisture Content	Specific Gravity	LL	PI	USCS
MIP37	30-34	0	1.3	22.7	92.3	99.9	30.2				
MIP37	20-24	0	6.6	35.4	70.9	99.7	38.6				
MIP37	36-40	0	0.8	14.7	84.9	96.2	24.6				
MIP35	20-24	0	7.3	38.5	70.7	89.5	23.2				
MIP09	20-24	0.1	5.6	21.2	60.1	94.4	24.4				
MIP06	20-24	0	6	34.1	65.5	92.1	25.9				
MIP06	16-20	0	2.5	12.5	36.1	99.5	42.7				
MIP10	24-28	0	1.9	10.9	29	99.3	47.5				
MIP36	24-28	0	3.1	16.5	34.5	86.5	25.2				

Lake Wales, FL

20/30 sand	1.19	1	0.84	0.71	0.59	0.5	0.42	0.3	
20/30 sand	99.5	94.2	73.3	41.7	13.8	3.6	1.2	0.2	passing
20/30 sand	0.5	5.8	26.7	58.3	86.2	96.4	98.8	99.8	retained

Lake Wales, FL

30/45 sand	0.84	0.71	0.59	0.5	0.42	0.35	0.297	0.25	0.21	0.149	
30/45 sand	99.7	98.6	86.8	49.4	18.3	6.7	1.8	0.4	0.2	0	passing
30/45 sand	0.3	1.4	13.2	50.6	81.7	93.3	98.2	99.6	99.8	100	retained

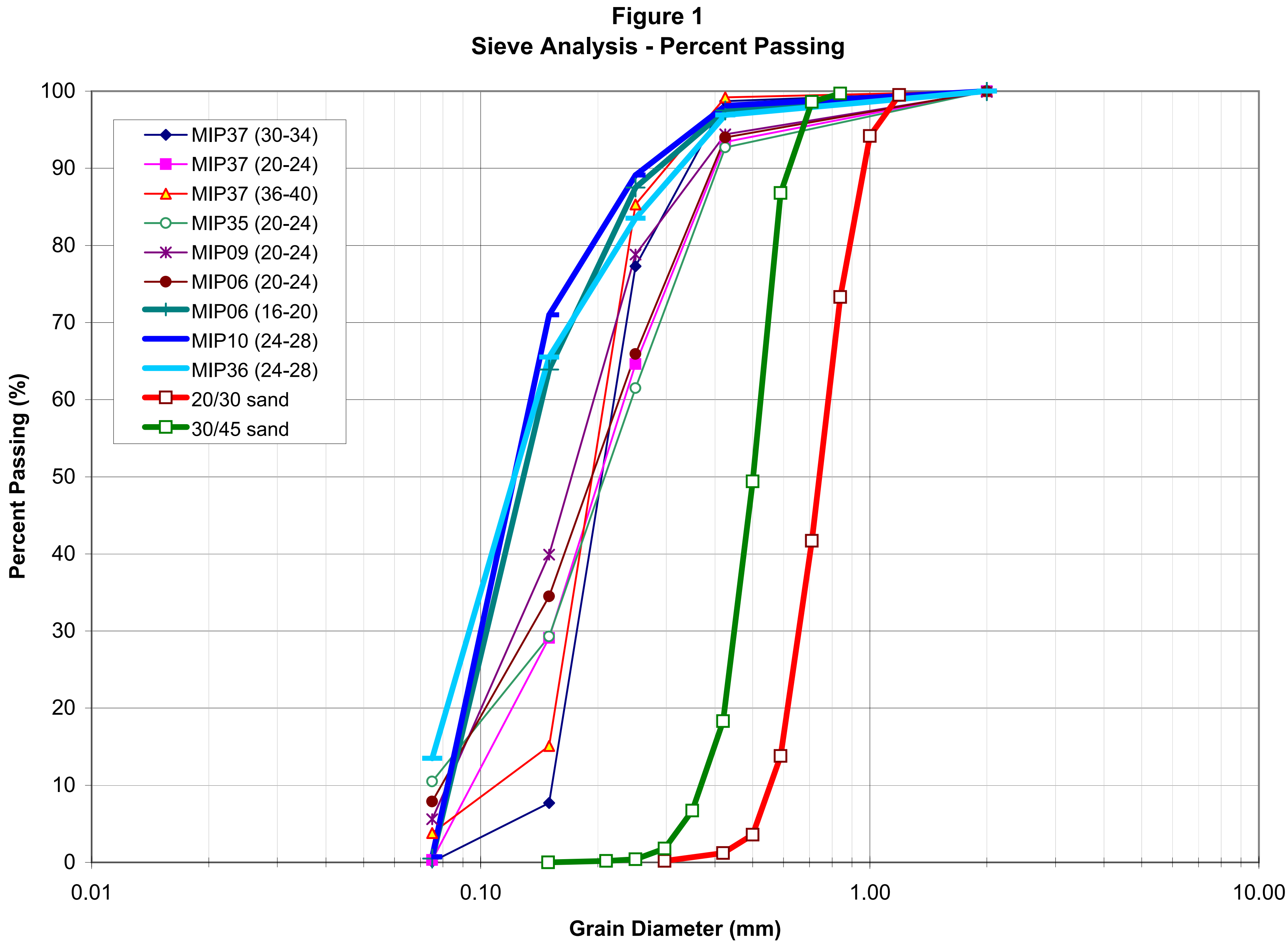
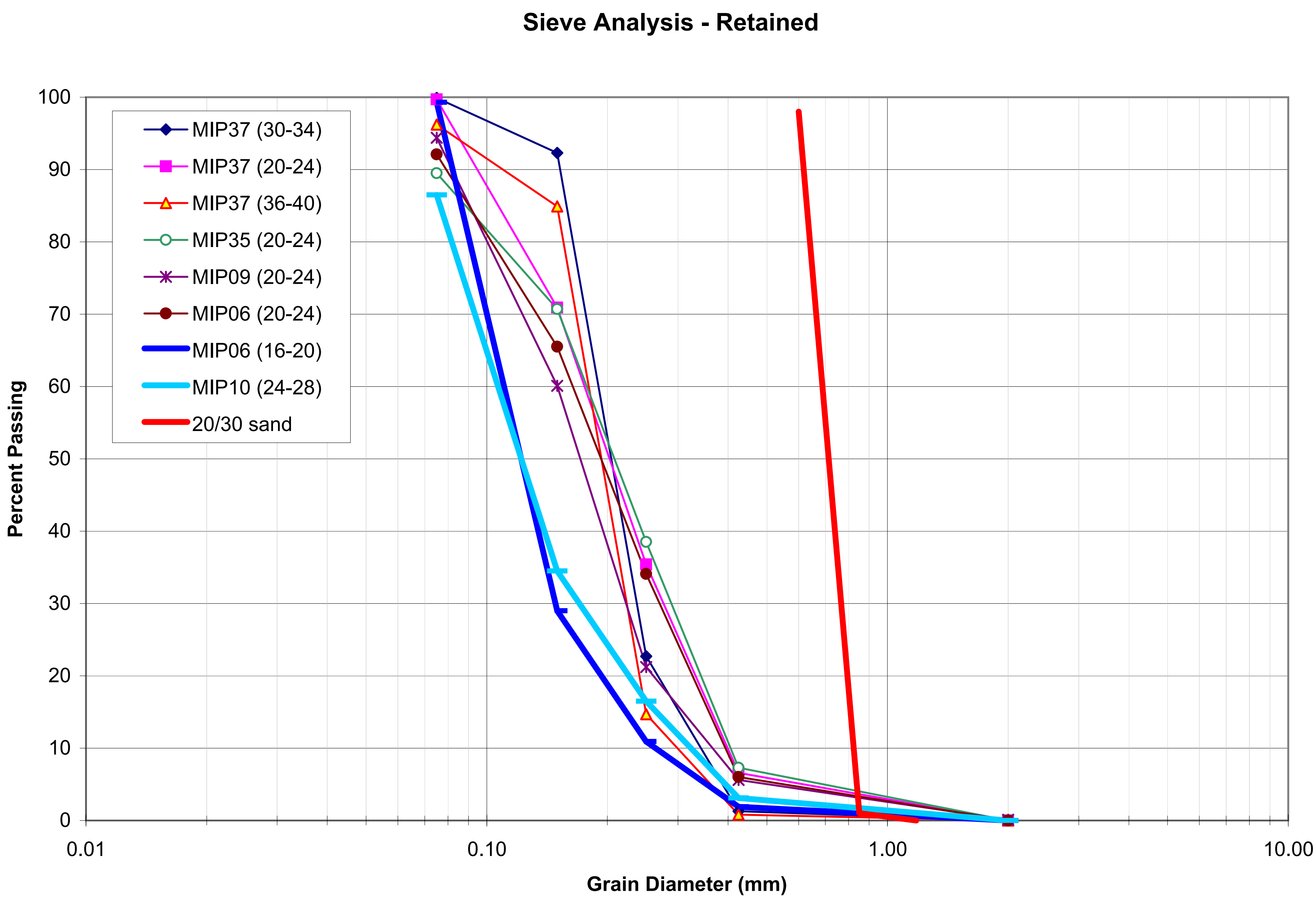


Figure 1
Sieve Analysis - Percent Passing
Percent Passing (%)
Grain Diameter (mm)
0
10
20
30
40
50
60
70
80
90
100
0.01
0.10
1.00
10.00
MIP37 (30-34)
MIP37 (20-24)
MIP37 (36-40)
MIP35 (20-24)
MIP09 (20-24)
MIP06 (20-24)
MIP06 (16-20)
MIP10 (24-28)
MIP36 (24-28)
20/30 sand
30/45 sand



Sieve Analysis - Retained
Percent Passing
Grain Diameter (mm)
0
10
20
30
40
50
60
70
80
90
100
0.01
0.10
1.00
10.00
MIP37 (30-34)
MIP37 (20-24)
MIP37 (36-40)
MIP35 (20-24)
MIP09 (20-24)
MIP06 (20-24)
MIP06 (16-20)
MIP10 (24-28)
20/30 sand

Appendix I

Evaluation of EOS® Viscosity Effects on Hydraulic Conductivity and Well Filter Pack Specifications

ORL NTC SA-17 Spreadsheet to Correct Site K for effects of EOS Viscosity wge-pjf 2006

% EOS solution	k[1]	g	Cp	ratio	Hydraulic Conductivity, K corrected for EOS viscosity m/s	ft/day	Cp Error Bounds
20	2.00E-12	9.80	1.004E-06	3.00	6.51E-06	1.84	
	2.00E-12	9.80	1.004E-06	2.40	8.13E-06	2.31	-20%
	2.00E-12	9.80	1.004E-06	3.60	5.42E-06	1.54	+20%
10	2.00E-12	9.80	1.004E-06	1.75	1.12E-05	3.16	
	2.00E-12	9.80	1.004E-06	1.40	1.39E-05	3.95	-20%
	2.00E-12	9.80	1.004E-06	2.10	9.30E-06	2.63	+20%
5	2.00E-12	9.80	1.004E-06	1.50	1.30E-05	3.69	
	2.00E-12	9.80	1.004E-06	1.20	1.63E-05	4.61	-20%
	2.00E-12	9.80	1.004E-06	1.80	1.08E-05	3.07	+20%
3	2.00E-12	9.80	1.004E-06	1.30	1.50E-05	4.26	
	2.00E-12	9.80	1.004E-06	1.04	1.88E-05	5.32	-20%
	2.00E-12	9.80	1.004E-06	1.56	1.25E-05	3.55	+20%
1	2.00E-12	9.80	1.004E-06	1.20	1.63E-05	4.61	
	2.00E-12	9.80	1.004E-06	0.96	2.03E-05	5.76	-20%
	2.00E-12	9.80	1.004E-06	1.44	1.36E-05	3.84	+20%

k = site specific intrinsic permeability - 1- NOTE: must be calculated for each site
g = acceleration due to gravity, average
Cp = kinematic vicsosity of water @ 20 degrees C
ratio = ratio of viscosity of EOS to water @ 20 degrees C
m/s = corrected site hydraulic conductivity K in meters per second
ft/day = corrected site hydraulic conductivity in feet per day
Cp Error Bounds = error bounds for Solutions' EOS viscosity data,
based on stated 20% error for water viscosity

SUBJECT	OPL-NTC SA-17	BY	WGE	DATE	01/04/06
	EOS EFFECTS ON AQUIFER	SHEET NO.	1	OF	2
	HYDRAULIC CONDUCTIVITY —	PROJECT NO.			

BASED ON GRAPHS OF EOS VISCOSITY + DENSITY (FROM SOLUTIONS INC.) OF A 60% SOYBEAN EMULSION @ 20°C

OIL CONC. % BY WEIGHT	(RATIO TO H2O) KINEMATIC VISCOSITY, ν	SPECIFIC GRAVITY
20	3.0	0.990
10	1.75	0.992
5	1.50	0.995
3	1.30	0.997
1	1.20	0.998

(KINEMATIC VISCOSITY OF WATER @ 20°C $= 1.0 \times 10^{-6}$ m²/SEC (1.004))

TO ADJUST HYDRAULIC CONDUCTIVITY (K) FOR VISCOSITY OF SOLUTION, MUST SOLVE FOR INTRINSIC PERMEABILITY, (K_i)

$$K_i = K \cdot \frac{\text{VISCOSITY}}{\text{GRAVITY}} = K\left(\frac{\nu}{g}\right)$$

WHERE $g = 9.8\ m/s^2$ (ACCEL. DUE TO GRAVITY)

IF $\frac{\text{K FOR SA-17,}}{\text{AVERAGE}} = 5.6\ \text{FT/DAY} \times \frac{1\ \text{m/DAY}}{3.28\ \text{FT/DAY}} \times \frac{1\ \text{DAY}}{86{,}400\ \text{SEC}} = 1.97 \times 10^{-5}\ \text{m/SEC}$

$$\text{THEN } K_i = \underset{(K)\ \cdot}{1.97 \times 10^{-5}\ \text{m/sec}} \underset{\left(\frac{\nu}{g}\right)}{\left(\frac{1.004 \times 10^{-6}\ \text{m}^2/\text{sec}}{9.8\ \text{m/sec}^2}\right)} = 2.0 \times 10^{-12}\ \text{m}^2$$

TO ADJUST HYDRAULIC CONDUCTIVITY (K), USE FORMULA FROM FREEZE + CHERRY: $K = K_i\left(\frac{g}{\nu}\right)$ + ADJUST ν BY THE KINEMATIC VISCOSITY RATIOS ABOVE AT EACH DESIRED CONCENTRATION — 1, 3, 5, 10, 20% —

- ERROR CORRECTION OF ±20% MUST BE APPLIED TO RESULTS DUE TO ERROR IN GRAPHS, WHERE SOLUTIONS EXPERIMENTS DERIVED VISCOSITY OF WATER AS 1.22 INSTEAD OF 1.0 CENTIPOISE —

$$K = K_i \cdot \left(\frac{g}{\nu}\right)$$, ADJUSTING ν FOR EOS EFFECT

FOR A 20% SOLUTION: $K_{20} = 2.0\times10^{-12}\,m^2 \left(\frac{9.8\,m/sec^2}{1.004\times10^{-6}\,m^2/sec \cdot 3.0}\right)$

FROM TABLE

$K_{20} = 6.5\times10^{-6}\,m/sec \times 86{,}400\,sec/day \times 3.28\,ft/m$

CORRECTED: $K_{20} =$ 1.84 FT/DAY ± 20% ERROR = $\boxed{\text{1.54 TO 2.31 FT/DAY}}$

FOR A 10% SOLUTION: $K_{10} = 2.0\times10^{-12}\,m^2 \left(\frac{9.8\,m/sec^2}{1.004\times10^{-6}\,m^2/sec \cdot 1.75}\right)$

$K_{10} = 1.12\times10^{-6}\,m/sec \times \frac{86400\,sec}{1\,day} \times \frac{3.28\,feet}{1\,m}$

$K_{10} =$ 3.16 FT/DAY ± 20% ERROR = $\boxed{\text{2.63 TO 3.95 FT/DAY}}$

FOR A 5% SOLUTION: $K_5 = 2.0\times10^{-12}\,m^2 \left(\frac{9.8\,m/sec^2}{1.004\times10^{-6}\,m^2/sec \cdot 1.50}\right)$

$K_5 = 1.3\times10^{-5}\,m/sec \times \frac{86400\,sec}{1\,day} \times \frac{3.28\,feet}{1\,m}$

$K_5 =$ 3.68 FT/DAY ± 20% ERROR = $\boxed{\text{3.07 TO 4.61 FT/DAY}}$

FOR A 3% SOLUTION: $K_3 = 2.0\times10^{-12}\,m^2 \left(\frac{9.8\,m/sec^2}{1.004\times10^{-6}\,m^2/sec \cdot 1.30}\right)$

$K_3 = 1.5\times10^{-5}\,m/sec \times \frac{86400\,sec}{1\,day} \times \frac{3.28\,ft}{1\,m}$

$K_3 =$ 4.25 FT/DAY ± 20% ERROR = $\boxed{\text{3.55 TO 5.32 FT/DAY}}$

FOR A 1% SOLUTION: $K_1 = 2.0\times10^{-12}\,m^2 \left(\frac{9.8\,m/sec^2}{1.004\times10^{-6}\,m^2/sec \cdot 1.20}\right)$

$K_1 = 1.6\times10^{-5}\,m/sec \times \frac{86{,}400\,sec}{1\,day} \times \frac{3.28\,ft}{1\,m}$

$K_1 =$ 4.61 FT/DAY ± 20% ERROR = $\boxed{\text{3.84 TO 5.76 FT/DAY}}$

3.1.2.3 Density

The density of concentrated oil emulsions is between 0.96 and 1.00 g/ml and varies as a function of oil content. Figure 3.6 shows the specific gravity of a commercially available emulsion (60% by weight soybean oil) when diluted in varying amounts of water. The manufacturers typically recommend that this material be diluted 19:1 to 4:1 with water prior to injection (3 to 12% final oil concentration), so the injected emulsion will have a specific gravity (ratio of emulsion density to water) between 0.994 and 0.999. Given the small difference in density between the diluted emulsion and water, buoyancy effects are not expected to be significant. These density effects can be further reduced by adding dissolved solutes (salts or sodium lactate) to increase the emulsion density.

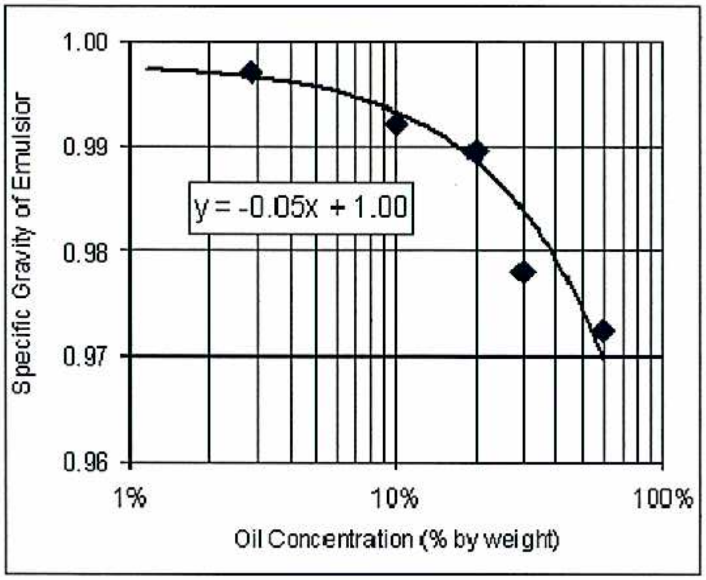


Figure 3.6 **Specific gravity of EOS 598B emulsion diluted with varying amounts of water.** (Data provided courtesy of EOS Remediation, Inc., Raleigh, NC.)

Concentrated emulsions can be highly viscous (e.g., mayonnaise). However, oil-in-water emulsions commonly used for groundwater remediation are typically much less viscous than NAPL oils and do not require any special equipment for handling. Figure 3.7 shows the density of a commercially available emulsion (60% by weight soybean oil) when diluted in varying amounts of water. Viscosity in Figure 3.7 is presented as the ratio of emulsion viscosity to water viscosity at 20 °C. The manufacturer typically recommends that this material be diluted 19:1 to 4:1 with water prior to injection (3 to 12% final oil concentration), so the injected emulsion will be between 1.3 and 2.1 times as viscous as water. The somewhat higher viscosity of the emulsion can result in a small increase in back pressure during the emulsion injection phase, but may also result in somewhat reduced fingering of the injection front.

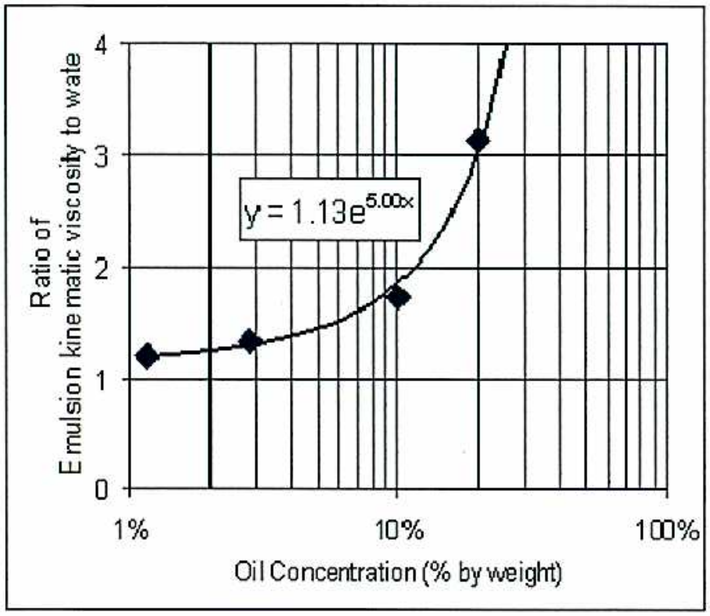


Figure 3.7 **Ratio of emulsion kinematic viscosity to water for EOS 598B emulsion diluted with varying amounts of water.** (Data provided courtesy of EOS Remediation, Inc., Raleigh, NC.)

Dynamic and Kinematic Viscosity of Water in SI Units:

Temperature - *t* (°C)	Dynamic Viscosity - μ 10^{-3} (N.s/m^2)	Kinematic Viscosity - v 10^{-6} (m^2/s)
0	1.787	1.787
5	1.519	1.519
10	1.307	1.307
20	1.002	1.004
30	0.798	0.801
40	0.653	0.658
50	0.547	0.553
60	0.467	0.475
70	0.404	0.413
80	0.355	0.365
90	0.315	0.326
100	0.282	0.294

Dynamic and Kinematic Viscosity of Water in Imperial Units (BG units):

Temperature - t (^{o}F)	Dynamic Viscosity - μ 10^{-5} ($lb.s/ft^2$)	Kinematic Viscosity - v 10^{-5} (ft^2/s)
32	3.732	1.924
40	3.228	1.664
50	2.730	1.407
60	2.344	1.210
70	2.034	1.052
80	1.791	0.926
90	1.500	0.823
100	1.423	0.738
120	1.164	0.607
140	0.974	0.511
160	0.832	0.439
180	0.721	0.383
200	0.634	0.339
212	0.589	0.317

Percent Passing

Boring Number	Sample Depth	No. 10 2.000	No. 40 0.425	No. 60 0.250	No. 100 0.150	No. 200 0.075	Moisture Content	Specific Gravity	LL	PI	USCS
MIP37	30-34	100	98.7	77.3	7.7	0.1	30.2				
MIP37	20-24	100	93.4	64.6	29.1	0.3	38.6				
MIP37	36-40	100	99.2	85.3	15.1	3.8	24.6				
MIP35	20-24	100	92.7	61.5	29.3	10.5	23.2				
MIP09	20-24	99.9	94.4	78.8	39.9	5.6	24.4				
MIP06	20-24	100	94	65.9	34.5	7.9	25.9				
MIP06	16-20	100	97.5	87.5	63.9	0.5	42.7				
MIP10	24-28	100	98.1	89.1	71	0.7	47.5				
MIP36	24-28	100	96.9	83.5	65.5	13.5	25.2				

Percent Retained

Boring Number	Sample Depth	No. 10 2.000	No. 40 0.425	No. 60 0.250	No. 100 0.150	No. 200 0.075	Moisture Content	Specific Gravity	LL	PI	USCS
MIP37	30-34	0	1.3	22.7	92.3	99.9	30.2				
MIP37	20-24	0	6.6	35.4	70.9	99.7	38.6				
MIP37	36-40	0	0.8	14.7	84.9	96.2	24.6				
MIP35	20-24	0	7.3	38.5	70.7	89.5	23.2				
MIP09	20-24	0.1	5.6	21.2	60.1	94.4	24.4				
MIP06	20-24	0	6	34.1	65.5	92.1	25.9				
MIP06	16-20	0	2.5	12.5	36.1	99.5	42.7				
MIP10	24-28	0	1.9	10.9	29	99.3	47.5				
MIP36	24-28	0	3.1	16.5	34.5	86.5	25.2				

Lake Wales, FL

20/30 sand	1.19	1	0.84	0.71	0.59	0.5	0.42	0.3		
20/30 sand	99.5	94.2	73.3	41.7	13.8	3.6	1.2	0.2	passing	
20/30 sand	0.5	5.8	26.7	58.3	86.2	96.4	98.8	99.8	retained	

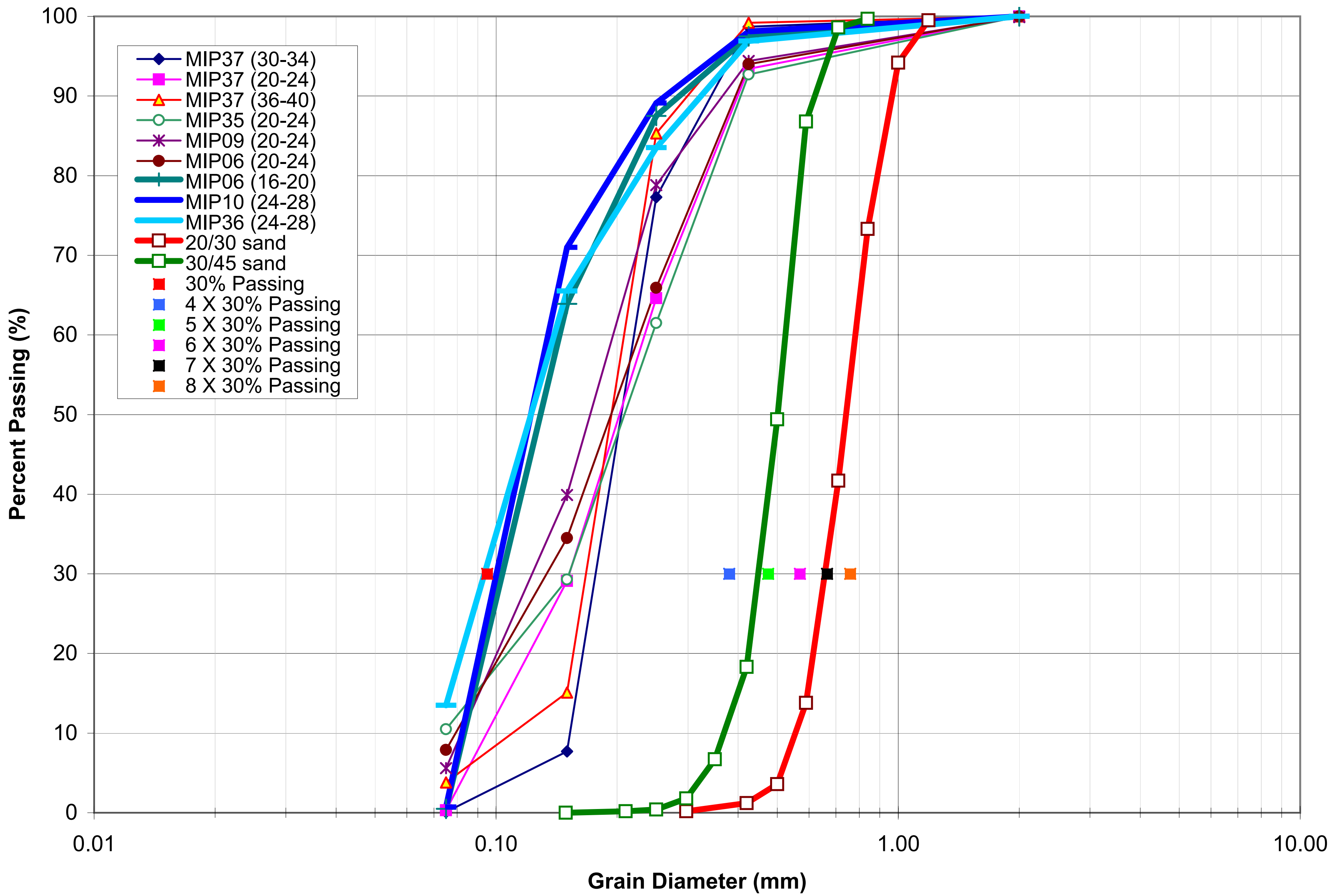
Lake Wales, FL

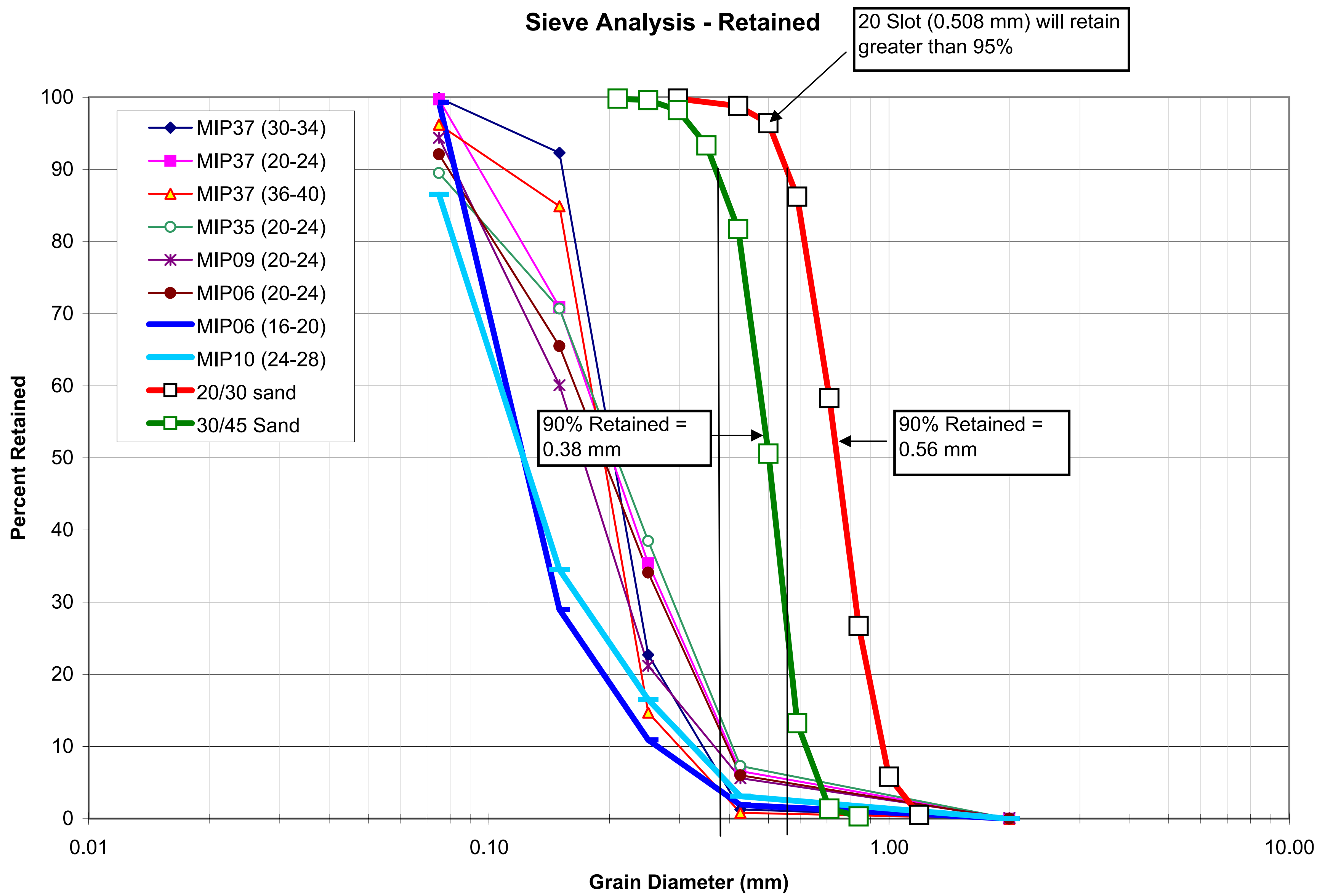
30/45 sand	0.84	0.71	0.59	0.5	0.42	0.35	0.297	0.25	0.21	0.149	
30/45 sand	99.7	98.6	86.8	49.4	18.3	6.7	1.8	0.4	0.2	0	passing
30/45 sand	0.3	1.4	13.2	50.6	81.7	93.3	98.2	99.6	99.8	100	retained

4-8 % 30% Passing

0.095	70	30
0.38	70	30
0.475	70	30
0.57	70	30
0.665	70	30
0.76	70	30

Figure 1
Sieve Analysis - Percent Passing





Sieve Analysis - Retained
20 Slot (0.508 mm) will retain greater than 95%
90% Retained = 0.38 mm
90% Retained = 0.56 mm
MIP37 (30-34)
MIP37 (20-24)
MIP37 (36-40)
MIP35 (20-24)
MIP09 (20-24)
MIP06 (20-24)
MIP06 (16-20)
MIP10 (24-28)
20/30 sand
30/45 Sand
Percent Retained
Grain Diameter (mm)
0
10
20
30
40
50
60
70
80
90
100
0.01
0.10
1.00
10.00